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(54) Improved multichannel gas analyzer

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Description

Technical Field

The present invention relates to systems for measuring the partial pressures of constituent gases in a gas stream. More specifically, the invention relates to improved multichannel gas analyzer systems used to measure the partial pressures of constituent gases in respiratory gas streams and display representative gas information on a CRT display.

Background

During surgery, anesthetized patients are usually intubated. Measurement of respiratory gases is desirable when a patient is mechanically intubated through an endo-tracheal tube. An analysis of the inhaled and exhaled gas mixture provides information about the patient's ventilation.

Carbon dioxide (CO_2), nitrous oxide (N_2O) and the anesthetic agent are the constituent gases of most interest in measuring respiratory gas streams.

It is well known that CO_2 in the bloodstream equilibrates rapidly with CO_2 in the lungs. Hence, the partial pressure of the CO_2 in the lungs approaches the amount in the blood during each breath. Accordingly, the CO_2 content at breath's end, termed end-tidal CO_2, is a good indication of the blood CO_2 level.

Abnormally high end-tidal CO_2 values indicate that an insufficient amount of CO_2 is being transported away from the bloodstream through the lungs, i.e., inadequate ventilation. Conversely, abnormally low end-tidal CO_2 values indicate poor blood flow to the tissues, inadequate CO_2 transport through the lungs, or excessive ventilation.

Mass spectrometers are used for measuring the partial pressure of respiratory gases in, for example, operating room suites in which one spectrometer is shared by many rooms. Mass spectrometers have the advantage of measuring a multiplicity of gases; however, the disadvantages are their cost, maintenance and calibration requirements, slow response time,and noncontinuous measurement.

Gas analyzers using non-dispersive infrared spectrophotometry are also used for partial pressure gas measurement. While these analyzers are less expensive than mass spectrometers and continuously measure partial gas pressure, their disadvantages are poor response time and difficulty in calibration.

Prior art non-dispersive infrared gas analyzers include features for making CO_2 and N_2O cross channel detection, temperature, and collision broadening corrections to their partial gas pressure measurements. Some of these corrections are made automatically by the analyzers while others are made manually by the operator.

Non-dispersive infrared gas analyzers generally have two configurations. The first, and most common, is the sampling or side-stream type. This type diverts a portion of the patient's respiratory gas flow through a sample tube to the infrared analyzer.

The second type mounts on the patient's airway and uses a portion of the airway as the sample chamber. This type is frequently occluded by the mucus and moisture in the patient's airway and its bulk on the airway can affect the patient's breathing.

The present invention overcomes these and other problems of prior infrared gas analyzers as will be set forth in the remainder of the specification.

An airway adapter assembly for such an analyser is shown in WO 86/02820. The adapter shown in WO 86/2820 comprises an assembly connected in series with a patient's airway tube for inducting sample gas through a sample tube to gas analyser means. The adapter further includes filter means through which sample gas passes from the airway tube to the sample tube in one direction.

US Patent No. 3705478 relates to a system for analysis in a gas chromatography unit. The unit is connected to a gas supply by a sample line having a filter. The filter may be backflushed by blowback gas pumped in a direction opposite to the normal gas flow direction.

According to the invention thee is provided a system for backflushing an inlet filter in an airway adapter in a gas sampling system, the system having a sample conduit for transporting therethrough a sample gas stream from the airway adapter to a gas analyzing means, with the sample gas stream passing through the inlet filter in a first direction to enter the sample conduit, characterised in that said system comprises a backflush conduit with means connected to the pressure side of a fluid pumping means and the airway adapter, and the fluid pumping means for causing a fluid flow in the backflush conduit from the fluid pumping means to the airway adapter and through the inlet filter in a second direction that is opposite the first direction the airway adapter including a valve member for restricting reverse fluid flow in the backflush conduit, a first section having means through which a respiratory gas stream passes,

a second section fixed in an opening in a sidewall of the first section and extending outwardly therefrom, the second section having a central cavity in fluid communication with the respiratory gas stream passing through the first section,
the valve member disposed in the cavity in the second section, the valve member having first and second means for fluid communications therethrough;
the inlet filter disposed across the central cavity between the valve member and the respiratory gas stream which the central cavity is in fluid communications with; and,
means for receiving therein and connecting the backflush conduit and sampling conduit comprising a coupling member adapted to mate in a fluid-tight

relationship with the central cavity of the second section of the airway adapter, and the sampling conduit being in fluid communication with the respiratory gas stream through the coupling member and the first means in the valve member
and the backflush conduit being in fluid communication with the respiratory gas stream through the coupling member and the second means in the valve member when the coupling member is mated with the second section.

The patient module of the system includes an optical bench with associated circuitry. This circuitry generates signals representative of the partial pressures of CO_2 and N_2O present in a respiratory gas stream transiting a gas pathway, the reference optical path, the temperature within the optical bench, and the pressure within the gas pathway.

The system pump module to a large extent controls system pneumatics. The module has means to draw a respiratory gas stream through the optical bench gas pathway for measurement of CO_2 and N_2O. The module also has means for measuring the flow rate of the gas steam through the optical bench gas pathway. Two valves in the pump module redirect the respiratory gas stream through an external device for measurement of other constituents of interest in the gas stream when configured to do so. The module's diagnostic valve together with other valves, the sample pump, and the flow sensor is used to test the fluid-tight integrity of the gas pathway.

With respect to system pneumatics, the patient module includes a zero valve, which when properly configured, is used with the pump module to supply scrubbed room air to the optical bench to make zero gas readings.

Analog input circuitry is electrically connected to the patient module including the optical bench. This circuitry receives the signals output from the optical bench and other patient module circuits. Analog input circuitry processes these signals and among other things converts them from analog to digital signals. The analog input circuitry then outputs the digital signals to the analog processing circuitry.

Analog processing circuitry, which includes a microprocessor, performs calculating functions. The results are output signals indicative of the partial pressure of CO_2 and N_2O corrected for temperature, pressure in the gas pathway, collision broadening, cross-correction, and characterization. These signals along with those for the measureD values of flow rate, pressure, and temperature are output to the display section of the system.

Display section circuitry, according to its programming, processes the signals output from the analog processing circuitry. The signals output from display section circuitry drive a CRT for display of graphics and characters representative of the partial pressures of the gases of interest and other measured values from the patient module.

The optical bench has two optical detection channel assemblies for measuring CO_2 and N_2O in the respiratory gas stream and the reference optical path associated with the CO_2 and N_2O detection channel assemblies. The bench continuously measures these gases at a rate which allows separate analysis of the inspired and expired gas mixtures. The optical bench circuitry preliminarily processes the signals output from the gas detectors and other detectors such as a pressure measurement sensor and a temperature measurement sensor.

The two optical detection channel assemblies and the connected detection circuitry are incorporated in the optical bench which is part of the small patient module. The patient module connects to a larger apparatus constituting the remainder gas analyzer system.

A double lumen tube, preferably one yard long or less, connects the patient module to a sidestream type patient airway adapter. The double lumen tube comprises a sample tube and backflush tube. The walls of the sample tube absorb water vapor condensing on them and evaporate it into the atmosphere which constitutes one-way water vapor transmission from within the sample tube. An optical bench entrance filter provides redundant protection of the optical bench gas pathway.

A flow shaper at the entrance of the optical bench gas pathway reshapes the sample tube gas flow cross-section from round to rectangular. In the optical bench gas pathway, the gas stream passes through the CO_2 abd N_2O detection channel assemblies in succession as it transits the gas pathway.

After leaving the optical bench gas pathway, the gas stream enters an absolute-type pressure transducer. The gas stream then leaves the absolute-type pressure transducer and enters the pump module. In this module the gas stream passes through the flow sensor and the sample pump. After leaving the pump module, the gas stream enters a scavenging tube and is exhausted from the system.

The main circuits of the display section are the display processor circuitry and pixel circuitry. The display processor circuitry bi-directionally communicates with the analog processor circuitry and controls the pixel circuitry. This control results in driving the CRT to display both the fixed characters and scrolled information, e.g., a capnogram.

Preferably, the CRT displays numerical and graphical data. The numerical data normally displayed are the inspired and expired values for CO_2 and N_2O, and respiration rate. The graphical data normally displayed is the CO_2 waveform. This waveform is an indication of the patient's respiratory cycle. Superimposed on, for example, the CO_2 waveform are the transition points between inspiration and expiration, and between expiration and inspiration. These points are marked with an "I" and an "E", respectively. The "I" and "E" markings provide the physician with the locations of selected transition points in both normal and abnormal capnograms.

An object of the invention is to provide an improved apparatus which has an patient airway adapter and the backflush system which insures that a patient will not be contaminated by virus or bacteria, for example, existing in the optical bench when a backflush is performed to clear occlusions of the airway adapter filter due to mucus or other material.

The object of the invention will be described more fully in the remaining portions of the specification.

Brief Description of the Drawings

Figure 1 is a block diagram of the multichannel gas analyzer system of the present invention.

Figure 2A is a cross-section view of the connector for connecting a double lumen tube to the patient airway adapter of the multichannel gas analyzer system of the present invention.

Figures 2B and 2C are two different cross-sectional views of the patient airway adapter of the multichannel gas analyzer system of the present invention.

Figure 4A is a block diagram of the pneumatics of the multichannel gas analyzer system of the present invention.

Figure 4B shows schematic diagrams of drive circuits for various components associated with control of the pneumatics.

Figure 5A is a schematic diagram of the optical bench circuitry of the multichannel gas analyzer system of the present invention.

Figure 5B shows schematic diagrams of drive circuits in the optical bench for various components associated with control of the pneumatics.

Figure 6A is a top view of the-chopper wheel of the optical bench of the multichannel gas analyzer system of the present invention.

Figure 6B is a top view of the chopper wheel of Figure 6A associated with selected portions in the optical bench of the multichannel gas analyzer system of the present invention.

Figure 6C are waveforms associated with gas and reference optical path detection, and demodulation.

Figure 7A-7D comprise a schematic diagram of the analog input circuitry of the multichannel gas analyzer system of the present invention.

Figures 8A-8C comprise a schematic diagram of the analog processing circuitry of the multichannel gas analyzer system of the present invention.

Detailed Description of the Preferred Embodiments

The present invention is an improved multichannel gas analyzer system for measuring the partial pressures of gases of interest in a respiratory gas stream. The analyzer system also displays numerical and graphical information about detected gases.

The figures refer to electronic components, or circuitry which consist of a group of components, which carry out a known specific function. Those components or circuit elements that are well known by those skilled in the art will be referred to generally by their common names or functions and are not explained in detail.

Analog section 102 and patient airway adapter 106 are described generally and in detail in discussing Figures 2A through 8C. Display section 104 is described generally and in detail in discussing Figures 9A through 15.

Figure 1 is a schematic diagram of the multichannel gas analyzer system of the present invention. The system comprises patient airway adapter 106, analog section 102, and display section 104. Analog section 102 detects and measures certain constituent gases in a respiratory gas stream. This section also detects and measures other physical properties which affect the determination of the partial pressures of constituent gases, e.g., CO_2, and N_2O. The measured values for CO_2, N_2O, and the other physical properties are combined to calculate the "real" partial pressure of CO_2 and N_2O. The "real" partial pressures of these gases are corrected for barometric pressure, optical bench pressure, temperature, collision broadening, cross-correction, and characterization of the detection circuitry and other detection components.

The calculated values for the partial pressures of CO_2 and N_2O are output from analog section 102 in digital form to display section 104. Analog section 102 also transmits measured values for flow rate, pressure, and temperature to the display section.

Display section 104 processes the analog section signals. The CO_2 and N_2O signals are processed for display on the CRT as numeric characters. The display section also processes at least the CO_2 signals for graphic display as, for example, a scrolling capnogram. The display section processes the pressure, flow rate, and temperature signals for display or as historical data.

The display section has system controls for operator interface. These controls select system operation and choice of screen displays. The display section also has both digital and analog output ports for communicating with peripheral equipment. The display section includes visual and audible alarms to indicate alarm conditions or improper system operation.

The analog processor circuitry can receive input signals from another optical bench for processing for display on the CRT. The other optical bench is dedicated to measurement of the partial pressures of other gases of interest in the respiratory gas stream.

Analog section 102 comprises patient module 109 which includes optical bench 111 (whose electronics include optical bench circuitry 118); pump module 112; analog input circuitry 122; and analog processing circuitry 124.

Display section 104 comprises display processing circuitry 128; pixel logic circuitry 130 (which include analog outputs); digital outputs 140; speaker driver 152; alarm and knobs 144; 5-button panel 148; and display

motherboard 137 (which includes a CRT driver). The powering system includes power supply 158, rectifier 160, and DC-DC converter 162.

Patient airway adapter 106 and tubes 172 and 174 (which form a double lumen tube that connects adapter 106 and patient module 109) are not part of analog section 102. The airway adapter can be detachably fixed to tubes 172 and 174. The adapter and tubes, besides being used in-part as a gas pathway from the patient to the patient module, provides a novel means for backflushing the adapter without risk of contaminating a patient with virus or bacteria that may exist in the optical bench gas pathway or sample tube 174.

Measurement accuracy increases the closer to the patient gas detection is made. For this reason, the length of the double lumen is preferably one yard or less.

Referring to Figures 2A, 2B, and 2C, the double lumen tube, its associated connector, and patient airway adapter 106 will be described. The double lumen tube containing sample tube 174 and backflush tube 172 connects airway adapter 106 and patient module 109. The series *of* dots at 170 represent the outer cover which encases gas sample tube 172 and backflush tube 174.

The walls of the sample tube, preferably constructed of Nafion, absorb and then evaporate condensed water vapor in the tube. Nafion is commercially available from E. I. du Pont de Nemours and Company, Wilmington, Delaware. Nafion is a trademark of E. I. du Pont and Company, Wilmington Delaware.

Connector body 178 has gripping members 180 which along with locking cap 176 secure outer cover I70 of the double lumen tube to connector body 178. Connector body 178 has annular bead 188 which assists in locking the connector body within airway adapter 106. O-ring 190 is disposed in annular groove 186. O-ring 190 is used to provide a fluid-tight seal between connector body 178 and airway adapter section 210.

Connector body 178 has central bore 182. Plug 184 is disposed in one end of the connector body and receives tubes 172 and 174. Plug 184 has separate openings for receiving backflush tube 172 and sample tube 174 therethrough.

The other end of central bore 182 has insert 192 disposed therein. Insert 192 has centrally disposed orifice 196 which connects to a larger diameter end opening 194. The end of sample tube 174 is disposed in orifice 196 so that it is in fluid communication with end opening 194.

Backflush tube 172 passes through plug 184 and is in fluid communication with central bore 182. Channels 198 and 200 are for fluid communication between central bore 182 and annular channel 201 in the end of connector body 178. Channel 201 is concentric with end opening 194. Accordingly, backflush tube 172 is in fluid communication with the end of the connector body.

Figures 2B and 2C show two different cross-sectional views of airway adapter 106. Accordingly, the following description applies to both figures.

Connector body 178 mates with section 210 of airway adapter 106. Section 210 has central cavity 212 which has disposed within it valve body 216 and valve member 226. Valve body 216 and valve member 226 are disposed on annular ledge 224 within cavity 212. Valve member 226 is disposed between valve body 216 and annular ledge 224.

Valve body 216 has centrally aligned nipple 217 on the side facing cavity 212 and centrally aligned nipple 219 on the opposite side. Orifice 218 extends through the center of the centrally aligned nipples. Concentric with nipple 217 is annular channel 220. Orifices 222 extend from the bottom annular channel 220 through the remaining thickness of valve body 216.

Valve member 226 has an opening in the center through which nipple 219 extends. In the valve's closed position, the edge of the opening in valve member 226 rests against the sides of nipple 219 and in cross-section forms an acute angles with the side of that nipple. This is necessary for proper operation of the valve.

Annular ledge 228 is fixed to the walls of opening 230 at the end nearest the valve. Hydrophobic filter 232 is disposed across opening 230 on the side of ledge 228 closest airway adapter section 238. Hydrophobic filter 232 can be fixed to annular ledge 228. However, in the preferred embodiment, annular ledge is not included and the filter is fixed to ledge 229. When annular ledge 228 is included, it seals the filter in place and prevents valve member 226 from contacting filter 232 when it is open and portions thereof move toward the filter.

Second section 238 of airway adapter 106 has opening 236 into which first section 210 is fixed. Section 238 has passage 240 through which respiratory gas to be sampled flows. section 238 is usually disposed in the patient's airway.

When connector body 178 is inserted into cavity 212, annular bead 214 at the end of the cavity moves over annular bead 188 on connector body 178. Accordingly, annular bead 188 rests in annular depression 215. This locks the connector body within the airway adapter. O-ring 190 rests against the interior wall of section 210 to seal against fluid leaks. End opening 194 of connector body 178 fits over nipple 217 of valve body 216. This places sample tube 174 in fluid communication with the respiratory gas flow in passage 240 through orifice 218 and filter 232.

When connector body 178 is locked in section 210, annular channel 201 in the end of connector body 178 is in fluid communication with annular channel 220 in valve body 216. Since orifices 222 are in fluid communication with passage 240 through valve member 226 and filter 232, backflush tube 172 is in uni-directional fluid communication with passage 240 of section 238.

In normal sampling operations, sample pump 358 (Figure 4A) in the pump module draws the gas sample through filter 232, orifice 218, and sample tube 174. Valve member 226 prevents the sample gas from enter-

ing backflush tube 172.

When filter 232 becomes occluded with mucus or other material requiring a backflush to clear it, zero valve 376 (Figure 4A) has its flow configuration changed so that the flow through sample tube 174 is cut off. Backflush pump 394 is activated and pumps filtered room air at a desired rate into backflush line 172 toward airway adapter 106. The filtered room air passes from backflush tube 172 through central bore 182, channels 198 and 200, and into annular channel 201 in the end of connector body 178. From the connector body, the backflush air enters annular channel 220 in valve body 216 and passes through orifices 222 in valve body 216. When the pressure of filtered room is great enough, valve member 226 lifts from its seat against the sides of nipple 219 allowing the filtered room air to clear filter 232 of the obstruction. Hence, the airway adapter can be backflushed without the possibility of backflushing any contamination that exists in the sample tube or the optical bench gas pathway into the patient when backflushing filter 232. Preferably, filter 232 is constructed of expanded PTFE with a 1 micron pore size.

The airway adapter has been described as involving the joining two separate sections, specifically, sections 210 and 238. However, it is understood that the airway adapter can be of unitary construction.

Figure 4A shows the pneumatic system which includes pump module 112 and certain components and inter-connected tubing in the patient module 109. The pneumatic system's purpose is to draw a respiratory gas stream through the gas pathway at the preferred rate of 50 cc/min., backflush the system with filtered room air at a flow rate of approximately 300 cc/min., draw scrubbed room air at a 50 cc/min. flow rate through the gas pathway for making zero gas measurements, and provide means for determining whether or not the gas pathway is fluid-tight.

The main components of pump module 112 includes flow sensor 356, sample pump 358, external valve 1, 424, external valve 2, 436, backflush pump 394, CO_2 scrubber 410, and diagnostic valve 412. The main components of the pneumatic system in patient module 109 are pressure sensor 374, zero valve 376, and backflush valve 382.

In normal operation, sample pump 358 is used to draw the respiratory gas stream through the patient module so that optical bench 111 can make measurements of the partial pressures of CO_2 and N_2O in the respiratory gas stream. SAMPLE PUMP+ line 360 and SAMPLE PUMP- line 362 are the power lines for sample pump 358. The voltaqe across these lines controls the speed of this pump. Preferably, the pump will run at a speed sufficient to maintain a 50 cc/min. respiratory gas flow rate through the gas pathway comprising sample tube 174, patient module sample gas pathway 372, optical bench gas pathway 298 (Figure 3), and pump module sample gas pathway 368. When this is the case, sample pump 358 is activated and a respiratory gas stream is drawn through airway adapter 106 and into sample tube 174. The gas then passes through filter 384 in connector 352 and through filter 386 across the inlet of the patient module sample gas pathway.

The respiratory gas stream proceeds through zero valve 376, which is configured for receiving the flow from sample tube 174. As it moves along the patient module sample gas pathway, it passes through optical inlet filter 312 and enters the optical bench gas pathway 298 (Figure 3) where measurements of the partial pressures of the gases of interest are made.

The respiratory gas stream leaves the optical bench and passes through pressure sensor 374. Pressure sensor 374 measures the pressure of the gas stream in the optical bench. The respiratory gas then flows through the remainder of patient module sample gas pathway 372 and enters pump module 112 through connector 370.

Once inside the pump module, the gas stream enters pump module sample gas pathway 368. First the gas stream passes through external valve 1, 424, and external valve 2, 436, configured for flow along pump module gas pathway 368 without redirection. After this, it passes through flow sensor 356 and sample pump 358. After leaving sample pump 358, the gas stream passes through connector 366 and enters a tube which carries the gas stream to a scavenging system.

When it is desired to make a zero gas reading, the direction of fluid flow through the zero valve is changed. During the time when zero gas readings are being made, barometric pressure readings are also made. The barometric pressure value is stored for use later in calculating the partial pressures on the gases of interest. Barometric pressure measurements are made with pressure sensor 374.

ZERO+ line 378 and ZERO- line 380 power zero valve 376. The voltage across these lines determines whether the zero value is configured to provide scrubbed room air from patient module zero gas pathway 404 or the respiratory gas stream from sample tube 174. Accordingly, the proper voltage is placed across ZERO+ line 378 and ZERO- line 380 to cause zero valve to close off gas flow from sample tube 174 and open to the air flow in patient module zero gas pathway 404. Preferably, sample pump is powered to draw 50 cc/min. of scrubbed room air through the pneumatic system.

When zero valve 376 is so aligned, sample pump 358 is properly activated and draws the scrubbed room air through the patient and pump modules' sample gas pathways. During this time, zero gas readings are made. The purpose of making zero gas readings is to clear the analyzer electronics so subsequent gas readings will be accurate.

When zero gas readings are being made, room air is draw through filter 414 and two-way diagnostic valve 412. The use of diagnostic valve 412 will be described subsequently. After diagnostic valve 412, the room air enters CO_2 scrubber 410. The CO_2 scrubber prevents,

for example, exhaled CO_2 from a system operator from entering the pneumatic system during zero gas readings.

Following the CO_2 scrubbing, the room air enters pump module zero gas pathway 408, goes through connector 406 and enters patient module zero gas pathway 404. After passing through zero valve 376, the scrubbed room air enters optical bench 111 where zero gas readings are made. Following this, the scrubbed room air goes through the remaining portions of the sample gas pathway in the patient and pump modules and enters the scavenging system.

During, or subsequent to, zero gas readings, or when it is determined that the patient adapter filter is clogged, a backflush is performed. To accomplish a backflush, first, zero valve 376 is configured to close off the sample gas flow from sample tube 174, and second, backflush valve 382 must be opened. BACKFLUSH+ line 420 and BACKFLUSH-line 422 are the power lines for backflush valve 382. Accordingly, the appropriate voltage is applied across the power lines to open it.

Now, backflush pump 394 must be activated. The backflush pump 394 is activated by the voltage across BACKFLUSH PUMP+ line 396 and BACKFLUSH PUMP-line 398. Once backflush pump 394 is properly powered, room air is drawn through filter 402 and enters pump module backflush pathway 392. The room air next passes through pump 394. After passing through the backflush pump, the room air goes through remainder of pump module backflush pathway 392 and connector 390, and enters patient module backflush pathway 388. Once the room air has passed through backflush valve 382, it then enters the backflush tube 172 enroute airway adapter 106. The filtered room air enters airway adapter 106 and clears the filter.

Two-way diagnostic valve 412 together with the zero valve, sample pump and pressure sensor is used to determine if the pneumatic system tubing or components are fluid-tight. When it is desired to check the fluid-tight integrity, two-way diagnostic valve 412 is configured to close off room air from entering the system. Two-way diagnostic valve 412 is powered by the voltage across DIAG+ line 416 and DIAG- line 418. After properly powering the valve, the system is set-up as if zero gas readings were to be made. The sample pump is activated to draw a vacuum in the sample and zero gas pathways of the patient and pump modules. Once a predetermined pressure is reached, the sample pump is deactivated. The pressure readings are monitored to see if there is a pressure change over time which would indicate that there are leaks in the system.

The partial pressures of other gases of interest in the respiratory gas stream are also measured. This is accomplished by external module 430. The pneumatic system of the present invention is such that the respiratory gas stream and the zero gas stream can be routed through external module 430.

External valve 1, 424, and external valve 2, 436, are disposed along pump module sample gas pathway 368 between connector 370 and flow sensor 356. Both valves are two-way valves.

EXT 1+ line 432 and EXT 1- line 434 are the power lines for external valve 1. EXT 2+ line 442 and EXT 2- line 444 are the power lines for the external valve 2. The voltages across these pairs determine whether the sample respiratory gas stream or zero gas stream are directed through pump module sample gas pathway 368 without redirection through external module 430.

When it is desired to route the respiratory gas stream or zero gas stream through external module 430, the proper voltage is placed across EXT 1+ line 432 and EXT 1- line 434, and placed across EXT 2+, line 442 and EXT 2- line 444 to configure external valve 1 and external valve 2 for this purpose. When these valves have this configuration, external value 1 closes off the direction of gas flow through pump module gas pathway 368 toward external valve 2, and opens toward external-in gas pathway 425; and external valve 2 closes off pump module gas pathway 368 in the direction of external valve 1 and opens toward external-out gas pathway 437.

Once external valve 1 and external valve 2 are powered to the above configuration, the respiratory gas stream or zero gas stream passes through external valve 1 and enters external-in gas pathway 425 in the pump module. The gas stream then passes through connector 426 and enters external module-in gas pathway 428. The gas stream upon leaving this gas pathway enters the external module 430's internal gas pathway. Measurements of the partial pressures of other gases of interest are made as the gas stream transits the external module's internal gas pathway.

When the gas stream exits the external module, it enters external module-out gas pathway 440. The gas stream then passes through connector 438 and enters external-out gas pathway 437 in pump module 112. The gas stream then enters external valve 2 where it is routed to pump module sample gas pathway 368.

Flow sensor 356 measures the flow rate of the sample respiratory gas stream or zero gas stream that passes through patient module 109. Flow sensor 356 is a differential pressure transducer. This transducer is commercially available from IC Sensors, Inc., Sunnyvale, California. For a 50 cc/min. flow rate, restriction in pump module gas pathway 368 that precedes flow sensor 356 produces a pressure drop of approximately 0.5 psi. The reference side of the pressure transducer connects to one side of the restriction and the measurement side connects the other. A change in the flow rate causes a change in the pressure drop which is measured by the transducer. Such changes generate representative voltages which are output as the FLOW PRS signal on line 391. The FLOW PRS RTN signal on line 393 is tied to ground.

Within flow sensor 356, prior to output therefrom, the detected voltage is input to a fixed gain differential

amplifier circuit. This amplifier circuit includes a potentiometer which is set to correct for span factor. The amplified and span factor corrected voltage representation to flow rate is output on line 391 as the FLOW PRS signal. The FLOW PRS signal and the FLOW PRS RTN signal (ground) are input to the analog processing circuits 124 for further processing as will be described.

Figure 4B shows the powering circuits for backflush pump 394, diagnostic valve 412, external valve 1, 424, and external valve 2, 436. The circuit for powering sample pump 358 is in the analog processing circuitry and will be discussed subsequently.

The circuits for powering the backflush pump, the diagnostic valve, the external valve 1, and the external valve 2 are subtantially the same. Therefore, the generation of the powering voltages for the backflush pump will be described and the signal names and reference numbers for the other three will follow in parentheses in the following order: the diagnostic valve, the external valve 1, and external valve 2.

The BACKFLUSH (DIAGNOSTIC, EXTERNAL VALVE 1, and EXTERNAL VALVE 2) signal on line 417 (411, 431, 441) is input to the base of transistor 413 (415, 433, 443). The BACKFLUSH (DIAGNOSTIC, EXTERNAL VALVE 1, and EXTERNAL VALVE 2) signal voltage determines whether the BACKFLUSH PUMP- (DIAG-, EXT 1-, and EXT 2-) signal is grounded to establish a voltage difference between the BACKFLUSH PUMP+ (DIAG+, EXT 1+, and EXT 2+) and the BACKFLUSH PUMP- (DIAG-, EXT 1-, and EXT 2-) signals. Diode 423 (419, 435, 445) protects the transistor when it is turned off.

Figure 5A is a schematic diagram of the circuitry and selected components of optical bench 109. Figure 5A shows cross-section views of sample gas pathway 298, CO_2 reference cell 296, and N_2O reference cell 300. It is understood that the sample gas flow enters gas pathway 298 at the CO_2 detection channel assembly and exits at the N_2O detection channel assembly. Accordingly, the gas stream first travels past the CO_2 detection channel assembly comprising infrared light source 326, sapphire windows 342 and 295, source aperture 282, detector aperture 270, optical filter 266 and lead selenide detector 262. Next it passes the N_2O detection channel assembly comprising infrared light source 328, sapphire windows 344 and 297, source aperture 282, detector aperature 270, optical filter 268, and lead selenide detector detector 258. Chopper wheel 280, common to both detection channel assemblies, has openings for simultaneous detection of the CO_2 and N_2O gas signals, simultaneous detection of the CO_2 and N_2O reference optical path signals and simultaneous detection of a dark period for the CO_2 and N_2O channels.

Broad band optical energy from each infrared source is passed through the gas stream. The optical filters only pass a narrow infrared band associated with the absorption characteristics of the specific gas of interest when the chopper wheel has its openings aligned with the gas optical path and reference optical path of each detection channel assembly. The energy streams exiting the respective filters issue on the associated detector. A representation three-step waveform output from a detection channel assembly is shown at 466 in Figure 6C. The dark signal is shown at 468, the reference signal is shown at 470, and the gas signal is shown at 472. The amplitude of the gas and reference signals are indicative of the amount of energy within the filter's band transmitted through the gas stream in the gas pathway and the reference cell.

The output signal from CO_2 detector 262 on line 520 is input to low noise preamp 522. The output of low noise preamp 522 is input to amplifier 524. The output of amplifier 524 is the CO_2/CO_2 REF signal on line 526 which input to the analog input circuitry.

The output signal from N_2O detector 258 on line 540 is input to low noise preamp 542. The output of low noise preamp 542 is input to amplifier 546. The output of amplifier 546 is the N_2O/N_2O REF signal on line 548 which is input to the analog input circuitry.

Also generated are the POSITION TRACK and TIMING TRACK signals which are used for determining the occurrence of certain events during a timing cycle and providing the basic timing cycle based on one revolution of chopper wheel 280.

The position track optical path comprises LED 332, source aperture 282, detector aperture 270, and photodiode 256. The timing track optical path comprises LED 330, source aperture 282, detector aperture 270, and photodiode 254. The position track path is chopped by the gas signal openings in chopper wheel 280. The timing track optical path is chopped by the 90 timing track openings in chopper wheel 280.

The chopped infrared energy from LEDs 332 and 330 issue on position track photodiode 256 and timing track photodiode 254, respectively. The output of position track photodiode 256 on line 528 is input to amplifier 530. The output of amplifier 530 is the POSITION TRACK signal on line 532. The output of timing track photodiode 254 on line 534 is input to amplifier 536. The output of amplifier 536 is the TIMING TRACK signal on line 538. A representative POSITION TRACK signal is shown at 460 in Figure 6C and a representative TIMING TRACK signal is shown at 464 in Figure 6C. The POSITION TRACK and TIMING TRACK signals are input to the analog input circuitry for the generation of the GAS GATING, REF GATING, and DEMOD SYNC signals for demodulating and processing of the CO_2/CO_2 REF and N_2O/N_2O REF signals.

Referring to Figures 6A and 6B, a top view of chopper wheel 280 is shown. In Figure 6A the top of the chopper wheel is shown alone and in Figure 6B it is shown in relation to certain other components of the optical bench.

From the center of chopper wheel 280 outward, the first chopping means is timing track 452. Timing track

452 is in the optical path comprising of LED 330, source aperture 282, detector aperture 270 and photodiode 254. As stated, the output of the timing track optical path is shown at 464 of Figure 6C. The series of opening representing the timing track total 90, thereby giving a timing track cycle count of 90.

The next chopping means are on the gas channel openings at 281. There are three gas channel openings, each of which subtends 40° and they are spaced 120° apart. The openings are situated such that there is simultaneous detection of the partial pressures for CO_2 and N_2O as shown in Figure 6B.

Radially outward from the gas channel chopping means, the chopper wheel has three openings at 450 for chopping the CO_2 and N_2O reference optical paths. Each reference channel opening subtends 40° and they are spaced 120° apart. The openings are situated such that there is simultaneous detection of the CO_2 and N_2O reference optical paths.

In the rotation of the chopper wheel 280, there is 40° portion that precedes each reference opening and follows each gas channel opening. During this period, referred to as the "dark" period, a signal is detected whereby no infrared light issues on the CO_2 or N_2O detector. This is the base line signal from which the gas channel and reference channel signals are measured. This signal is removed from the gas channel and reference channel signals during signal processing resulting in the detected signals which are due only to the partial pressures of CO_2 and N_2O in respiratory gas stream and the CO_2 and N_2O reference optical paths.

Each timing cycle, or single rotation, of chopper wheel 280 has three detection subcycles comprising dark detection period, reference detection period, and gas detection period. A representative repeating three-stepped waveform pattern is shown at 466 in Figure 6C.

The position track optical path comprises LED 332, source aperature 282, detector aperture 270 with single slit 277 and photodiode 256. The gas channel openings are used to chop the position track optical path. The resultant signal is the square wave signal shown at 460 in Figure 6C. The POSITION TRACK signal, as will be described, is used to mark gas channel detection events.

The TIMING TRACK and POSITION TRACK signals in conjunction with PROM 656 (Figure 7A) are used to generate the GAS GATING, REF GATING and DEMOD SYNC signal waveforms shown in Figure 6C at 500, 488, and 476, respectively. These signals will be used to obtain useful information with respect to the detected CO_2 partial pressure and the N_2O partial pressure, and the reference optical path signal associated with each.

At this point, the only signals discussed which are ready for output from the optical bench are the detected CO_2/CO_2 REF signal, N_2O/N_2O REF signal, the TIMING TRACK signal, and the POSITION TRACK signal. The remainder of the signals output from the optical bench circuitry are the signals output from multiplexer 558 and the powering voltages for the backflush valve and the zero valve. The multiplexer and its associated signals will be discussed then the generation of the powering voltages will be discussed.

The first input to multiplexer 558 is the output of EEPROM 580. EEPROM 580 stores coefficients relating to characterization of the optical bench.

The characterization coefficients do not adjust or change the operation of any component of the optical bench or the apparatus as a whole. These coefficients correct the bench's measurements for system component deviation from ideal.

The inputs to EEPROM 580 are the data bus DI signal on line 574, the SK (serial data clock) signal on line 576 and the CS (chip select) signal on line 578. The CS and SK signals control the EEPROM's output. The D1 signal is the data input to the EEPROM. These three signals are output from quad. flip flop 572. The data inputs to quad. flip flop 572 are optical bench data bus signals DØ-D2 on lines 567, 568, and 570, respectively. The DØ-D2 signals are three of the four outputs of line driver 560 whose inputs are the 4 bit parallel PREDØ-PRED3 signals on lines 561, 562, 564, and 566. These signals are from the analog input circuitry.

Quad. flip flop 572 is clocked by the output of decoder 598 on line 600. The inputs to decoder 598 are the BUS STROBE signal on line 592, the AI signal on line 594, and the A2 signal on line 596. These signals are output from line driver 584. The inputs to line driver 584 are the PRESTB signal on line 586, the PREAI signal on line 588, and the PREA2 signal on line 590. These signals are received from the analog input circuitry. Decoder 598 is enabled by the BUS STROBE signal and the output depends on the logic states of the AI and A2 signals. When properly instructed, the EEPROM outputs the characterization coefficients to multiplexer 558.

The second input to multiplexer 558 is the OB TEMP (optical bench temperature) signal on line 556. The bench temperature is sensed by temperature sensing and control circuit 554. The sensed temperature (in volts) on line 555 is input to differential receiver 557. The second input to differential receiver 557 on line 553 is tied to ground. The output of differential receiver 557 is input to multiplexer 558. Unlike many prior art optical benches which actively control optical bench temperature for accurate readings, the optical bench of the present inventions does not control the optical bench temperature.

The third input to multiplexer 558 is the signal represententive of the pressure in gas pathway 298 sensed by pressure sensor 374. The sensed signal is amplified by amplifier 551 and the amplified pressure signal on line 552 is input to multiplexer 558.

Pressure sensor 374 is an absolute pressure measuring type pressure sensor. The pressure sensor is commercially available from IC Sensors, Inc., Sunnyvale, California.

The pressure is continuously monitored during sys-

tem operation. Rapid pressure changes may indicate various problems in the optical bench. The pressure within the optical bench must be considered in calculating gas partial pressures for display, as more fully discussed.

The pressure sensor also measures barometric pressure at system start up. This value is stored in memory for later use. The stored value for barometric pressure is updated during every zero gas reading.

The fourth input to multiplexer 558 is the output of voltage reference 614. The input to voltage reference 614 is a +10v signal. Its output is the +5V REF signal on line 615 which is input to multiplexer 558.

The DØ-D3 signals of the optical bench data bus output from line driver 560 are input to quad. flip flop 606. This flip flop is clocked by the output of decoder 598 on line 602. When clocked, quad. flip flop 606 provides a parallel 3-bit signal on lines 608, 610, and 612 which is input to the control inputs to multiplexer 558. Based on the logic states of this 3-bit signal, a multiplexed signal is output from multiplexer 558 on line 559. The multiplexed signal on line 559 is processed by buffer amplifier 616 and output therefrom as the AMUX OUTPUT signal on 618. The AMUX OUTPUT signal is then sent to the analog input circuitry for further processing. Also output from multiplexer 558 and sent to the analog input circuitry is the AMUX RTN signal on line 620. This signal is tied to ground.

The DØ-D3 signals on line 566, 568, 570, and 572 are input to quad. flip flip 585. This flip flop is clocked by the output of demultiplexer 598 on line 604. The outputs of quad. flip flop 585 are the BACKFLUSH VALVE DRIVE signal on line 628, the ZERO VALVE INITIAL signal on line 636, and the ZERO VALVE HOLD signal on line 632. These signals control powering the backflush and zero valves.

Figures 5B shows the circuits for powering backflush valve 382 and zero valve 376 shown in Figure 4A. The BACKFLUSH VALVE DRIVE signal is input to the base of transistor 624. The BACKFLUSH VALVE DRIVE signal voltage determines whether the BACKFLUSH- signal on line 422 is grounded to establish a voltage difference between the BACKFLUSH+ signal on line 420 and the BACKFLUSH- signal on line 422. Diode 626 protects transistor 624 when it is turned off.

The circuit for powering zero valve 376 is for powering the zero valve initially, which requires a greater voltage, and for holding the valve in the changed position after initially powering it, which requires less voltage. The ZERO VALVE INITIAL signal on line 636 is input to the base of transistor 634. The ZERO VALVE INITIAL signal voltage determines whether the ZERO- signal on line 380 is grounded to establish a voltage difference between the ZERO+ signal on line 378 and the ZERO- signal on line 380. Diode 638 protects the transistor when it is turned off.

After initially powering zero voltage 376, the zero voltage is held in position by the following: The ZERO VALVE HOLD signal on line 632 is input to the base of transistor 630. The ZERO VALVE HOLD signal voltage determines whether or not the ZERO-signal on line 380 is grounded to establish a voltage difference between the ZERO+ signal on line 378 and the ZERO- signal on line 380. There is a voltage drop across resistor 631 thereby reducing the voltage difference between the ZERO+ line and the ZERO- line from what it would be normally without the resistor. Similarly, diode 638 protects the transistor when it is turned off.

Figures 7A-7D are schematic diagrams of analog input circuitry 122 (Figure 1). The inputs to this circuitry are primarily the analog outputs from optical bench 111 and signals from analog processing circuitry 124.

Referring to Figure 7A, the temperature of the analog circuitry is determined by REF-02, 690. The output of REF-02 is amplified by amplifier 694 and output therefrom as the V_T (Box temperature) signal on line 696. Also output from REF-02 is the V_{OFF} signal on line 692. This signal is used for insuring that the outputs associated with the gated gas and reference signals are at least zero. REF-02 is commercially available from Precision Monolithics, Inc., Santa Clara, California.

The generation of the gating signals and demodulation signals for use in obtaining useful information from the detected gas and reference signals, will be discussed. The TIMING TRACK signal on line 538 is the first input to differential receiver 640. The second input is the GAS RTN signal on line 668. This signal is tied to ground. The output of differential receiver 640 is input to pulse shaping circuit 642 which processes the incoming signal so that clean square waves are produced at its output. The output of pulse shaping circuit 640 on line 644 is input to the clock inputs of 4-bit counters 646 and 660, flip flops 672 and 676, and input to the clock input to octal flip flop 658.

The POSITION TRACK signal on line 532 is input to differential receiver 666. The second input is the GAS RTN signal on line 668. The output of differential receiver 666 is input to pulse shaping circuit 669, which like pulse shaping circuit 642, processes the incoming signal so that clean square waves are produced at its output. The output of pulse shaping circuit 669 is input to the data input of flip flop 672.

The negative-true Q bar output of flip flop 672 on line 674 is input to the data input of flip flop 676 and is also input as the first input to NAND gate 678. The negative-true Q bar output of flip flop 676 is the second input to NAND gate 678. The output of NAND gate 678 on line 680 is input to the "clear" inputs of counters 646 and 660. (The "bar" designation after a signal or input name indicates the inverted state of the signal or input without the bar designation, as is known by those skilled in the art).

Flip flops 672 and 676 are clocked by the processed TIMING TRACK signal. Accordingly, this serves to synchronize the POSITION TRACK signal with the TIMING TRACK signal.

The two flip flops and NAND gate cause clearing of the counters during the period from one TIMING TRACK signal after the beginning of the position track pulse to one TIMING TRACK signal after the end of a position track pulse. Therefore, the counters will count from the end of the position track pulse to the beginning of the next. Since the carryout output of counter is input to the enable inputs to counter 660, there is a continuous count until the counters are cleared.

Outputs of counter 646 on lines 648, 650, 652 and 654, and the outputs of counter 660 on lines 662 and 664, are input to PROM 656. PROM 656 is programmed for the waveform patterns for the GAS GATING, REF GATING, and DEMOD SYNC signals. Therefore, based on the logic values of the signals output from the counters, PROM 656 provides outputs to octal flip flop 658 that will produce the programmed waveform patterns for these signals. Accordingly, when octal flip flop 658 is clocked by the processed TIMING TRACK signal, its outputs are the GAS GATING signal on line 684, whose representative waveform is shown at 500 in Figure 6C; the REF GATING signal on line 686, whose representative waveform is shown at 488 in Figure 6C; and the DEMOD SYNC signal on line 688, whose representative waveform is shown at 476 in Figure 6C.

The FLOW PRS signal on line 391 is input to the differential receiver 702. The second input to the differential receiver is the FLOW PRS RTN signal on line 393. These signals are from flow sensor 356 in pump module 112. The output of differential receiver 702 is the FLOW PRS SIG signal on line 704.

The circuit in Figure 7A comprising high pass filters 708, peak detector 710, comparator 715, level buffer 716, and flip flop 718 is for detecting if the patient module has impacted something with such severity that the apparatus may need to perform a zero gas reading to continue to make accurate measurements.

The BUFFERED CO_2 signal on line 706 is input to high pass filters 708. The output *of* the high pass filters is input to peak detector 710. The peak detector provides outputs on lines 712 and 714 which are input to comparator 715. The output of comparator 715 is processed by the level buffer 716 and input to the clock input of flip flop 718. The Q output of flip flop 718 is the IMPACT signal on line 722.

When the system is turned on, the IMPACT RESET bar signal on line 720 has a logic "Ø" value to reset the flip flop 718. Accordingly, the Q output of the flip flop, which is the IMPACT signal, has in logic "Ø" value. The signal input to the data input of flip flop 718 is the +5v signal which, therefore, places a logic "1" value at the data input.

In operation, the BUFFERED CO_2 signal is first passed through the high pass filters. In the peak detector, the signal is divided down and the outputs of the peak detector that are input to the comparator are the basic signal and the divided down signal. The output of the comparator is a relatively steady state signal which is input to the clock input to the flip flop after level buffering.

When the apparatus suffers an impact of sufficient severity, there is a rapid change in the high frequency component. This will cause the comparator to provide an output which will clock flip flop 718. When the flip flop is clocked, the logic "1" value at its data input is output from the Q output as the IMPACT signal indicating that the apparatus has impacted something with sufficient severity that the apparatus may need to do a zero gas reading. When the IMPACT signal has a logic "1" value, it ultimately will cause an alarm to indicate this condition.

In the circuit in Figure 7B, the CO_2/CO_2 REF signal on line 526 and the N_2O/N_2O REF signal on line 548 are similarily demodulated, have the dark period signals removed therefrom each, and have each signal separated into the gas signal and the reference signal before input to multiplexer 838 (Figure 7C). Accordingly, the CO_2/CO_2 REF channel path will be described and the signal names and reference numbers for the N_2O/N_2O REF channel path will follow in parentheses.

The CO_2/CO_2 REF (N_2O/N_2O REF) signal on line 526 (548) is input to differential receiver 738 (750). The second input to differential receiver 738 (750) is the GAS RTN signal on line 668. The GAS RTN signal is tied to ground. The output of differential receiver 738 (750) is input to electronic switch 740 (752). The control input to electronic switch 740 (752) is the CO_2 CAL (N_2O CAL) signal on line 726 (734). The CO_2 CAL (N_2O CAL) signal will have the proper logic state to open the switch when it is desired to determine the system's offset voltage, as will be described subsequently; otherwise the switch is closed.

The output of electronic switch 740 (752) is input to variable gain amplifier 744 (756). The control inputs to variable gain amplifier 744 (756) are the DACEN A bar (DACEN B bar) signal on line 728 (736), the AIWR bar signal on line 730, and the parallel 8-bit data bus signals AIDØ-7 on line 732. The DACEN A bar (DACEN B bar) signal is input to the CE bar input, the AIWR bar signal is input to the WR bar input, and the AIDØ-7 is input to the parallel 8-bit input of the amplifier. Accordingly, when the AIDØ-7 signals are written into the amplifier, it will have a gain from 0 to 64 based on these values.

The output of variable gain amplifier 744 (756) is input to synchronous rectifier 748 (758). Line 706 connects to the output of variable gain amplifier 744. Line 706 contains the BUFFERED CO_2 signal that is input to the impact circuit in Figure 7A.

Synchronous rectifier 748 (758) demodulates the CO_2/CO_2 REF (N_2O/N_2O REF) signal by removing the dark period signal from the gas and reference signals. The demodulating signal input to synchronous rectifier 748 (758) is the DEMOD SYNC signal on line 688. The DEMOD SYNC signal waveform is shown at 476 of Figure 6C. As can be seen in Figure 6C, the DEMOD SYNC signal has a +1 value during the reference and gas periods, and a -1 value during the dark period. Accordingly,

the dark period signal is inverted while reference and gas period signals values are not. This results in the demodulated signal shown at 480 in Figure 6C, where the inverted dark period signal is shown at 482, and the non-inverted reference and gas signals are shown at 484 and 486, respectively.

The demodulated CO_2/CO_2 REF (N_2O/N_2O REF) signal output from synchronous rectifier 748 (758) on line 760 (761) is input to double switches 762 and 774 (788 and 802). As is shown for each, the switches are oppositely disposed: in double switch 762 (788), switch 770 (790) is open and switch 772 (792) is closed; and in double switch 774 (802), switch 776 (804) is open and switch 778 (806) is closed. When the Value input to the control inputs of double switches 762 and 774 (780 and 802) changes, then switches pairs will be change their respective open or closed conditions.

The control input to double switch 762 (788) is the GAS GATING signal on line 684 and the control input to double switch 774 (802) is the REF GATING signal on line 686. The GAS GATING signal controls the disposition of switches 770 (790) and 772 (792) according to the waveform shown at 500 in Figure 6C, and the REF GATING signal controls the disposition of switches 776 (804) and 778 (806) according to the waveform shown at 488 in Figure 6C.

The signal output from double switch 762 (788) is input to low pass filters 764 (796). The signal is output from the low pass filters and input to low pass filter 766 (798). The second input to low pass filter 766 (798) is the BUFFERED V_{OFF} signal on line 818. The BUFFERED V_{OFF} signal is input to low pass filters 766 (798) to insure that output is never less than zero.

The signal output from double switch 774 (802) is input to low pass filters 782 (810). The signal is output from the low pass filters and input to low pass filter 784 (812). The second input to low pass filter 784 (812) is the BUFFERED V_{OFF} signal on line 818. This signal insures that the output of low pass filter 784 (812) is never less than zero.

After gating, the CO_2(N_2O) signal has a waveform substantially as shown at 506 of Figure 6C, with the pulse at 508 being attributed to the dark period and the pulse at 510 being attributed to the partial pressure of CO_2 in the gas pathway. Similarly, after gating the CO_2 REF (N_2O REF) signal has a waveform substantially as shown at 494 in Figure 6C, with the pulse at 496 being attributed to the dark period and the pulse at 498 being attributed to the reference optical path. After filtering, the waveform outputs for CO_2 on line 768 and N_2O on line 800 are changing waveforms corresponding to the detected value for each gas. The CO_2 reference signal on line 786 and N_2O reference signal on line 814 are the current values for each reference optical path.

The inputs and outputs to interface 820 will now be discussed. The inputs to interface 820 are the MISC SEL bar signal on line 822, the AIRD bar signal on line 824, the AIWR bar signal on line 730, the IORESET signal on line 826, the analog input circuitry address bus signals AIA1-2 on line 828, and the analog input circuitry data bus signals AIDØ-7 on line 732.

The MISC SEL bar signal is input to the chip select input of interface 820. The AIRD bar and AIWR bar signals are input to the RD and WR inputs respectively to interface 820. The IORESET signal is input to the reset input to interface 820. The AIA1-2 signal and the AIDØ-7 signal are input respectively to address bus inputs and the data bus inputs.

The outputs of interface 820 are the 4-bit parallel PAØ-3 signal on line 830, the parallel 4-bit parallel ASØ-3 signal on line 832, the CO_2 CAL signal on line 726, the N_2O CAL signal on line 734 and the IMPACT RESET bar signal on line 720, and the IMPACT signal is input on line 722.

The PAØ-3 signal on line 830 is input to the control inputs to analog switch 926 (Figure 7D). The ASØ-3 signal on line 832 is input to the control inputs to multiplexer 838 (Figure 7C). The CO_2 CAL and N_2O CAL signals are input to electronic switches 740 and 752, respectively, for use in determining the offset voltages for the CO_2 and N_2O gas channels and the CO_2 REF and N_2O REF channels (Figure 7B). The IMPACT RESET bar and IMPACT signals are for use in the impact detection circuit (Figure 7A).

Referring to Figure 7C, placement of the certain analog signals on the analog input circuitry data bus will be described.

The inputs to multiplexier 838 are the AMUX signal on line 840, the BATT SEN signal on line 842 (from power supply circuitry 158, Figure 1), the CO_2 signal on line 768, the N_2O signal on line 800, the FLOW PRS SIG signal on line 704, the CO_2 REF signal on line 786, the N_2O REF signal on line 814, the V_T signal on line 696, the V MOT DRV signal on line 844, the $V_{OBSPEED}$ signal on line 846, the V_{OFF} signal on line 692, and the MOT CURR SEN signal on line 848. (Certain of these signals have been described while others have not; those that have not will be described subsequently).

The AMUX OUTPUT signal on line 618 and the AMUX RTN signal on line 620, both of which are output from multiplexer 558 (Figure 5A), are input to differential receiver 887. The output of differential receiver 887 on line 840 is the AMUX signal which is input to the multiplexer 838.

The parallel 4-bit signal ASØ-3 on line 832 from interface 820 is input to the control inputs of multiplexer 838. Based on the logic states these control signals, multiplexer 838 provides an output to buffer amplifier 850. The multiplexed analog output signal includes the analog values for the detected partial pressures of CO_2, CO_2 REF, N_2O, and N_2O REF; the flow rate of the gas through the optical bench; the pressure and temperature in the optical bench; the temperature of the apparatus containing the analog input circuitry; the speed of the chopper motor; the chopper motor drive voltage; the voltage for maintaining a positive amplifier output values

for selected amplifiers; the sensed battery voltage; the sensed motor current, the +5v reference; and the characterization information.

The signals input to interface 876 are the A/D SEL bar signal on line 874, the AIRD bar signal on line 824, the AIWR bar signal on line 730, the RESET signal on line 825, the parallel 2-bit address signal AIA1-2 on line 828, and the parallel 8-bit signal AIDØ-7 on line 732. The outputs of interface 876 will be discussed subsequently in discussing the circuit. Line 826 is connected to line 825 containing the RESET signal. Line 826 is redesignated the IORESET signal for use in the analog input circuitry.

The ANALOG OUTPUT signal on line 852 is input to differential receiver 854. The second input to differential receiver 854 is the system offset signal VDAC on line 856 which is an output of digital to analog (D/A) converter 879.

The offset signal for each of the four gas or reference channels is generated by opening switches 740 or 752 at the appropriate time (Figure 7B). The voltage output by D/A coverter 879 when these switches are open is that gas or reference channel's voltage offset. This channel offset is subtracted from the measured value for each gas.

The voltage difference output from differential receiver 854 is input to variable gain amplifier 860. The gain of the amplifier is controlled by the parallel 8-bit signal PAØ-PA7 output from interface 876. These signals are from analog input circuitry data bus 732.

The output of variable gain amplifier 860 is input to sample and hold circuit 862. The sample and hold circuit control signal is the S/H (H bar) signal output from interface 876 on line 882. The control signal will hold the sample and hold output signal long enough for conversion of the current data in successive approximation register 870; placement of that data on data bus 880; and input of the present sample and hold signal into the successive approximation register for conversion.

The output of the sample and hold circuit is input to comparator 866. The second input to comparator 866 is the VDAC signal on line 856. The output of comparator 866 is input to successive approximation register 870. The START SAR bar signal on line 886 is input to successive approximation register 870 to start the analog to digital conversion process. The SELSAR signal 884 is input to the output enable input of successive approximation register 870. The logic value of this signal controls placement of the converted data on data bus 880.

Another output of successive approximation register 870 is the CC INT bar signal on line 872 which will be discussed in connection with Figure 8A.

The SARCLK ENB signal output from interface 876 on line 888 is for generating the SARCLK signal on line 890 as will be discussed in connection with Figure 8B. This is the first input to NAND gate 1110 for this purpose. The other input to that gate is the CLK 400 signal output from microprocessor 960 on line 970. The states of these signals control the output of NAND gate 1110. The output of NAND gate 1110 after inversion, the SARCLK signal, is used to turn the internal successive approximation register clock on and off.

Figure 7D shows the remaining circuits of the analog input circuitry.

The PREAMP SEL bar signal on line 892 is input to NAND gate 894. The other input to this gate is the AIWR bar signal on line 730. The output of NAND gate 894 on line 898 clocks 8-bit latch 896. The inputs to 8-bit latch 896 are the AIDØ-3 signals from the analog input circuitry data bus on line 732 and AIA1-2 signals from the analog input circuitry address bus on line 828. The output of 8-bit latch 896 is input to 8-bit latch 900.

The signal that clocks latch 900 is the PCLK signal on line 902. The generation of the PCLK signal will be described when discussing Figure 8C. Also input to 8-bit latch 900 is the Q output of flip flop 918. Flip flop 918 is preset by the PSTRB on signal on line 916 and cleared by the output of NAND gate 894 on line 898.

The outputs of 8-bit latch 900 are the PDØ signal on line 904, the PD1 signal on line 906, the PD2 signal on line 908, the PD3 signal on line 910, the PA1 signal on line 912, the PA2 signal on line 914, and the PSTRB signal on line 916.

The parallel 4-bit input to line driver 922 from 8-bit latch 900 comprises the PDØ signal, the PD1 signal, the PA1 signal, and the PSTRB signal. The parallel 4-bit output of this driver is the PREDØ signal on line 561, the PRED1 signal on line 562, the PREA1 signal on line 588, and the PRESTRB signal on line 586.

The parallel 3-bit input to line driver 924 comprises the PD2 signal, the PA2 signal, and the PD3 signal. The parallel 3-bit output of this driver is the PRED2 signal on line 564, the PREA2 signal on line 590 and the PRED3 signal on 566.

FDØ-FD3/PREDØ-PRED3 are the data lines to the optical bench 4-bit data bus. PA1 and PA2/PREA1 and PREA2 are lines to the parallel 2-bit optical bench address bus. PSTRB/PRESTRB is the data line to the optical bench address bus and data bus strobe.

The VDAC signal on line 856 from D/A converter 879 is representative of the 12-bit converted data bus information. The VDAC signal is input to analog switch 926. The output signal from analog switch 926 on line 928 is processed by sample and hold circuit 930. The output of this circuit on line 932 is the OB MOTOR SPEED signal.

The output signal of analog switch 926 on line 934 is processed by sample and hold circuit 936. The output of this circuit is the AIR PUMP SPEED signal on line 938. The parallel 4-bit signal PAØ-3 on line 830 output from interface 820 is input to the control inputs of analog switch 926.

The TIMING TRACK signal on line 538 output from the detector circuitry is input to frequency to voltage converter 944. The frequency to voltage converter output voltage, $V_{OBSPEED}$, is input to the analog processing cir-

cuitry and to error amplifier 945. The $V_{OBSPEED}$ signal is a voltage signal proportional to the chopper motor speed.

The second input to error amplifier 945 is the OB MOTOR SPEED signal on line 932 from analog switch 926. This signal is the voltage set point for the chopper motor speed. The difference in the signals is input to the base of transistor 952. The base of transistor 948 is tied to leg 953 of transistor 952. When transistor 952 is in the "on" condition, this, under the proper conditions, will cause a voltage difference between the MOTOR DRIVE line 844 and the MOTOR RTN line 950, thereby providing the proper power to drive the chopper motor. When transistor 952 turns off, voltage is returned on line 844 which turns on transistor 948. This causes a braking action to help slow down the motor.

The MOT CURR SEN signal on line 848 is tied to leg 955 on the source side of transistor 952. The V MOT DRV signal is also designated 844 since it contains the same signal as the MOTOR DRIVE signal. Diode 946 blocks returned current on line 844 allowing transistor 948 to be turned on for braking.

The inputs to decoder 942 are the GAIN SEL bar signal on line 940 and the parallel 2-bit signal AIA1-2 from address bus 828. The GAIN SEL bar signal is input to the output enable input and the 2-bit address signal is input to the two control inputs of decoder 942. The logic values of the 2-bit address bus signal determine selection of the output. The outputs of decoder 942 are the DACEN A bar signal on line 728 and the DACEN B bar signal on line 736. These signals are the output enable signals for the variable gain amplifiers associated with processing the CO_2/CO_2 REF signal and N_2O/N_2O REF signal in Figure 7B.

Figures 8A, 8B and 8C show analog processing circuitry 124 (Figure 1). First the circuits of the analog processing circuitry will be described, then their calculating functions will be described.

Referring to Figure 8A, one component of analog processing circuitry 124 is microprocessor 960. Microprocessor 960 is a model 80186 CPU, commercially available from Intel Corp., Santa Clara, California.

The signals input to microprocessor 960 are from the circuitry in Figures 8B and 8C, and the analog input circuitry. These are the UART INT signal on line 962, the CC INT bar signal on line 872, the DRQØ signal on line 964, the DRQl signal on line 966 and the FST A signal on line 972.

The UART INT signal is an interrupt signal from controller 1059 to indicate the transmission or receipt of data. The CC INT signal is an interrupt input from successive approximation register 870 to indicate completion of the conversion of an analog signal input and that the converted signals can be put on the data bus 880 (Figure 7C). The DRQØ and DRQ1 signals are direct memory access request inputs indicating that a character is ready to be transmitted from memory or that a character has been received and must be transferred to memory. The FST A signal is the fail safe timer signal to indicate whether or not that the microprocessor has drifted off into an improper loop and is no longer performing its required functions.

The output signals of microprocessor 960 are the PATT SEL signal on line 974, the UCS bar signal on line 976, the PREAMP SEL' bar signal on line 978 the GAIN SEL' bar signal on line 980, the PATIENT SIDE OFF signal on line 982, the PUMP/VALVE SEL signal on line 984, the PCS5 signal on line 986, the ALE signal on line 988, the RESET signal on line 825, the UART CLK signal on line 968, the CLK 400 signal on line 970, the DT/R (R bar) signal on line 996, the DEN bar signal on line 997, the UART SEL signal on line 998, the A/D SEL' bar signal on line 1000, the MISC SEL' bar signal on line 1002, the CLK8 signal on line 1012, the WR bar signal -on 1004, the RD bar signal on line 1006, the LCS bar signal on line 1008, and the BHE bar signal on line 1010.

The PATT SEL signal is for generating the PCLK signal on line 902. The PCLK signal clocks latch 900 (Figure 7D) which contains values to be the placed on the optical bench data bus.

The UCS bar signal on line 976 enables decoder 1040.

The PREAMP SEL' bar signal, the GAIN SEL' bar signal, the A/D SEL' bar signal, the MISC SEL' signal, WR bar signal, and the RD bar signal are used for generating the PREAMP SEL signal on line 892, the GAIN SEL signal on line 940, the A/D SEL bar signal on line 872, the MISC SEL bar signal on line 822, the AIWR bar signal on line 830 and the AIRD bar signal on line 824, respectively, for use by the analog input circuitry shown in Figures 7A-7D.

The PREAMP SEL bar signal, the GAIN SEL bar signal, the A/D SEL bar signal, and the MISC SEL bar signal are chip selection inputs for components of the analog input circuitry. The AIWR bar and AIRD bar signals act as conventional write and read signals.

The CLK 400 signal is used in generating the SAR CLK signal on line 890 and the PCLK signal on line 902 (Figure 8C).

The DT/R (R bar) signal controls the direction of data flow through bus transceivers 1024, 1025, and 1106.

The DEN bar signal is the output enable signal for bus transceiver 1024 and 1025.

The PUMP/VALVE SEL signal is one of the signals controlling the selection among powering the diagnostic value, the backflush valve, the external valve 1, and/or the external valve 2.

The PCS5 signal is one of the signals used to generate the FST A signal on line 972 for determining if the microprocessor has entered an improper loop.

The LCS bar signal enables decoders 1032 and 1036.

The BEE bar signal is one of the control inputs to decoder 1036.

The UART SEL signal is input to the chip select input of controller 1059.

The ALE signal is for clocking address latches 1014, 1016, and 1018.

The CLK8 signal is the 8 MHZ clock signal for clocking various circuit components of the processor circuitry.

The WR bar signal is the write timing signal indicating that the processor is writing data into memory or into an input/output device.

The RD bar signal is a read timing signal indicating that the processor is reading data.

Memory in Figure 8A consists of four read only memories (ROMs-) 1046, 1048, 1054, and 1056; and two random access memories (RAMs) 1050 and 1052. This memory is conventionally connected to address bus 1022 and data bus 1028.

Figure 8A shows three address latches, 1014, 1016, and 1018. These latches are clocked by the ALE (address latch enable) signal input to their respective clock inputs. Hence, when the ALE signal has the proper logic state, the three latches are clocked simultaneously.

Latch 1014 receives a parallel 4-bit input from address outputs A16/S3-A19/S6 on line 990. The clocking of latch 1014 will place these values on address bus 1022.

The parallel 8-bit information signal AD8-15, output from microprocessor 960 on line 992, is input to latch 1016. The AD8-15 signal can contain either address or data information. However, when it is handling address information and those values are input to latch 1016, when that latch is clocked, the latched address values are placed on address bus 1022.

Similarly, the parallel 8-bit signal, ADØ-7, output from microprocessor 960 on line 994, is input to latch 1018. The ADØ-7 signal may contain address or data information. When it contains address information and the values are input to latch 1018, when that latch is clocked, the latched values are placed on address bus 1022.

The ADØ-15 signals also connect to data bus 1028 via bus 1020 and bus transceivers 1024 and 1025. Bus transceiver 1024 controls transfers between the ADØ-7 signals on bus 1020 and the data bus. Bus transceiver 1025 controls transfers between the AD8-15 signals on bus 1020 and the data bus. Bus transceivers 1024 and 1025 are enabled by the DEN bar signal on line 997. The direction of the data transfer is controlled by the DT/R (R bar) signal on line 996.

Decoders 1032 and 1036 are used to enable RAMs 1050 and 1052, respectively. The LCS bar signal on line 1008 enables both decoders. The first control signal input to decoder 1032 is the AØ signal from the address bus. The second control input is tied to ground. These signals are decoded to provide an input to the chip enable input of RAM 1050. Whether reading or writing is the proper action is determined by the logic states of the RD bar and WR bar signals input to RAM 1050.

The first control signal input to decoder 1036 is the the BHE bar signal on line 1010. The second control input is tied to ground. These signals are decoded to provide an input to the chip enable input of RAM 1052. Similarly, whether reading or writing is accomplished depends on the logic states of the RD bar and WR bar signals input to RAM 1052.

Third decoder 1040 enables ROMs 1046, 1048, 1054, and 1056. The UCS bar signal output from microprocessor 960 on line 976 enables decoder 1040. The control inputs to decoder 1040 are the A17, A18 and A19 signals from address bus 1022. When the control inputs are decoded, decoder 1040 provides outputs to enable the ROMs. Whether an enabled ROM can be read depends on the logic state of the RD bar signal input to the OE bar input of each ROM.

Referring to Figure 8B, controller 1059 will be discussed. The Q output of flip flop 1058 clocks controller 1059. The CLK8 signal on line 1012 clocks flip flop 1058. The Q bar output and data input of this flip flop are tied. Hence, the Q output will have a positive-going edge to clock controller 1059 every two CLK8 pulses.

The RESET signal on line 825 output from microprocessor 960 is input to to inverter 1007. Inverter 1007 changes the logic state of the RESET signal; accordingly; the RESET bar signal is input to the RESET bar input of controller 1059.

The WR bar signal on line 1004 and the RD bar signal on line 1006 are input to controller 1059. These signals control whether data is transmitted from or received by controller 1059.

The UART SEL signal on line 998 is input to controller 1059 for chip selection and enabling reading from and writing into memory.

The parallel 2-bit address bus signal, A12 and A13, from address bus 1022 is input to controller 1059. These are the address bus bits that control data flow. The parallel 8-bit data bus signal, DØ-7, on line 1028 is input to controller 1059. These are the data bus bits which are either read from or written onto.

The DRQØ signal on line 964 and the DRQ1 signal on line 966 are input to microprocessor 960 for notifying the microprocessor that data is ready to be transmitted from memory or that data is ready to be sent to memory.

The other signals that are output from or input to controller 1059 are primarily associated with communicating with the display section or an external device.

The INT CLK signal on line 1060 is the internal baud rate clock for synchronous serial communications between the analog and display processors.

The TxD INT signal on line 1062 is the line on which data is transmitted from the analog processor to the display processor.

The RxD INT signal on line 1064 is the line on which data is received from the display processor.

The information in the TxD INT signal on line 1062, the RxD INT signal on line I064, and the INT CLK signal on line 1060 is communicated between analog processing circuitry 124 and display processing circuitry 128 using these signals because the analog and the display

sections are electrically isolated.

The TxD INT signal is input to inverters 1080 and 1082 and then opto-isolator 1084. The TxD INT signal on the display side of opto-isolator 1084 is renamed the RXD INT signal on line 1086. A portion of data contained in the TxD INT signal is ultimately displayed on the CRT.

The RxD INT signal on line 1064 contains data received from the display processing circuitry. The signal starts as the TxD INT signal on line 1094 on the display side. The signal is input to inverters 1092 and 1090, and then opto-isolator 1088. At the output of opto-isolator 1088, the signal is renamed the RxD INT signal on line 1064.

The INT CLK signal on line 1060 is used to synchronously control transfer of data between the analog and display processing circuitry. The INT CLK signal on line 1078 on the display side is input to inverters 1074 and 1072, and then input to opto-isolator 1070. The signal is output from the opto-isolator on line 1060 for input to controller 1059.

The UART CLK signal on line 968 is input to controller 1059 and along with TxDB signal on line 1066 and the RxDB signal on line 1068 are for communications with external module 430 (Figure 4A).

The UART CLK signal on li-ne 968 is the baud rate clock for serial communications with the external module. The TxDB bar signal is for transmitting data to the external module. The RxDB bar signal is for receiving data from the external module.

The UART INT signal on line 962 is the UART INT bar signal output from controller 1059 after inversion by inverter 963. This signal is an interrupt signal to microprocessor 960 to indicate that data is ready to be sent or received.

The BATT SEN signal on line 842, and the FLOW PRS signal on line 391 and FLOW PRS RTN signal on line 393, cross the analog processing circuitry enroute to the analog input circuitry where they are processed.

The AIR PUMP SPEED signal on line 938 from analog switch 926 (Figure 7D) is input to the base of transistor 1114. This signal controls the SAMPLE PUMP+ voltage on line 1122. The SAMPLE PUMP- signal on line 1124 is tied to ground. The power delivered by the circuit is limited by fuse 1116 in line 1122 and by zener diodes 1118 and 1120. The voltage across these lines controls the speed of sample pump 358. (Figure 4A).

The DØ signal from data bus 1028 and the PCS5 signal from microprocessor 960 are input to the protection circuit 1125 according to a preset rate and duty cycle. The protection circuit, according the clock rate of the PCS5 signal, evaluates the DØ signal. If DØ has values indicative of improper operation or the PCS5 signal is absent, it indicates that the microprocessor is in an improper loop and not carrying out its required functions, the FST A signal on line 972 will change logic states. This will cause the activation of the appropriate alarms to indicate this condition.

The SAR CLK signal on line 890 (Figure 8A) which turns the internal clock of successive approximation register 870 on and off is generated by the CLK 400 signal and the SAR CLK ENBL signal. The CLK 400 signal on line 970 and the SAR CLK ENBL signal on line 888 are input to NAND gate 1110. The logic states of these signals control the output of NAND gate 1110. The output of NAND gate 1110 is inverted by inverter 1112 whose output is the SAR CLK signal on line 890.

The analog processing circuitry generates the control signals for powering certain components of the pump module. These are the diagnostic valve, the external valve 1, the external valve 2, and the backflush pump. The WR bar signal on line 1004 and the PUMP/VALVE SEL signal on line 984 are input to negative-true AND gate 1095. The output of negative-true AND gate 1095 is inverted by inverter 1096 and input to the clock input of 8-bit flip flop 1098 of which only 4-bits are output lines. The data input to flip flop 1098 are the DØ-7 signals from the data bus. When the flip flop is clocked, the data bus logic values determine which valves will be powered. Accordingly, the outputs of flip flop 1098 which are destined for the pump module are the DIAGNOSTIC VALVE signal on lines 411, the EXTERNAL VALVE 1 signal on line 431, the EXTERNAL VALVE 2 signal on line 441, and the BACKFLUSH signal on line 417.

The terms and expressions which are employed here are terms of description and not of limitation. There is no intention, in the use of such terms and expressions, to exclude the equivalents of the features shown and described, or portions thereof, it being recognised that various modifications are possible within the scope of the invention as claimed.

Claims

1. A system for backflushing an inlet filter (232) in an airway adapter (106) in a gas sampling system, the system having a sample conduit (174) for transporting therethrough a sample gas stream from the airway adapter (106) to a gas analyzing means (102), with the sample gas stream passing through the inlet filter (232) in a first direction to enter the sample conduit (176), characterised in that said system comprises a backflush conduit (172) with means connected to the pressure side of a fluid pumping means (394) and the airway adapter (106), and the fluid pumping means (394) for causing a fluid flow in the backflush conduit (172) from the fluid pumping means (394) to the airway adapter (106) and through the inlet filter (232) in a second direction that is opposite the first direction the airway adapter including a valve member (226) for restricting reverse fluid flow in the backflush conduit (172), a first section (240) having means through which a respiratory gas stream passes,

    a second section (210) fixed in an opening

(236) in a sidewall of the first section (240) and extending outwardly therefrom, the second section (210) having a central cavity (212) in fluid communication with the respiratory gas stream passing through the first section (240), the valve member (226) disposed in the cavity (212) in the second section (210), the valve member (226) having first and second means (218,. 222) for fluid communications therethrough;

the inlet filter (232) disposed across the central cavity (212) between the valve member (226) and the respiratory gas stream which the central cavity (212) is in fluid communications with; and,

means (178) for receiving therein and connecting the backflush conduit (172) and sampling conduit (174) comprising a coupling member (178) adapted to mate in a fluid-tight relationship with the central cavity (212) of the second section (210) of the airway adapter (108), and the sampling conduit (174) being in fluid communication with the respiratory gas system through the coupling member (178) and the first means (218) in the valve member (226)

and the backflush conduit (174) being in fluid communication with the respiratory gas stream through the coupling member (178) and the second means (222) in the valve member (226) when the coupling member (178) is mated with the second section (210).

2. A system according to claim 1, wherein the valve member (226) further comprises a disk-shaped valve body (216) with a centrally aligned first nipple (217) extending outwardly from a first flat surface and a centrally aligned second nipple (219) extending outwardly from a second flat surface on the opposite side of the disk-shaped valve body (216), with the first means (218) being a bore (218) extending through the first and second nipples (217, 219 (218)) and the valve body (216) therebetween, and the second means (222) being a series of bores (220, 222) through the valve body (216) concentric with the first and second nipples (217, 219) and a disk-shaped valving means (226) having a centrally disposed opening of sufficient size for ingress of the second nipple (219), with the valving means (226) being disposed from the second flat surface of the valve body (216) and fixed thereto at positions radially outward from the series of bores (220,222) comprising the second means, with the valving means (226) restricting fluid flow through the second means to one direction.

3. A system according to claim 1, wherein the valve member (226) is a uni-directional valve.

Patentansprüche

1. Vorrichtung zum Rückspülen eines Einlaßfilters (232) in einem Luftkanaladapter (106) in einem Gasprobenahmesystem, wobei das System eine Probenahmeleitung (174) hat, durch welche ein Probegasstrom von dem Luftkanaladapter (106) zu einer Gasanalysiereinrichtung (102) gefördert wird, und wobei der Probegasstrom durch den Einlaßfilter (232) in einer ersten Richtung geht, um in die Probenahmeleitung (176) einzutreten, **dadurch gekennzeichnet**, daß das System eine Rückspülleitung (172) mit einer Einrichtung aufweist, welche mit der Druckseite einer Fluidpumpeinrichtung (394) und dem Luftkanaladapter (106) verbunden ist, die Fluidpumpeinrichtung (394) bewirkt, daß ein Fluidstrom in der Rückspülleitung (172) von der Fluidpumpeinrichtung (394) zu dem Luftkanaladapter (106) und durch den Einlaßfilter (232) in eine zweite Richtung strömt, welche zur ersten Richtung entgegengesetzt ist, der Luftkanaladapter ein Ventilelement (226) umfaßt, welches den Rückfluidstrom in der Rückspülleitung (172) begrenzt, und ein erstes Teil (240) umfaßt, welches eine Einrichtung hat, durch die ein Atemgasstrom geht,

ein zweites Teil (210), das in einer Öffnung (236) in einer Seitenwand des ersten Teils (240) festgelegt ist, und sich von diesem nach außen erstreckt, das zweite Teil (210) einen zentralen Hohlraum (212) hat, welcher in kommunizierender Fluidverbindung mit dem Atemgasstrom ist, welcher durch das erste Teil (240) geht,

das Ventilelement (226) in dem Hohlraum (212) in dem zweiten Teil (210) angeordnet ist, das Ventilelement (226) erste und zweite Einrichtungen (218, 222) zur Herstellung einer kommunizierenden Fluidverbindung hierdurch hat;

der Einlaßfilter (232) an dem zentralen Hohlraum (212) zwischen dem Ventilelement (226) und dem Atemgasstrom angeordnet ist, mit dem der zentrale Hohlraum (212) in kommunizierender Fluidverbindung steht; und

eine Einrichtung (178) vorgesehen ist, welche die Rückspülleitung (172) aufnimmt und eine Verbindung mit dieser herstellt, und die Probenahmeleitung (174) ein Kupplungsteil (178) aufweist, welches derart beschaffen und ausgelegt ist, daß es unter Herstellung einer fluiddichten Verbindung mit dem zentralen Hohlraum (212) des zweiten Teils (210) des Luftkanaladapters (108) zusammenarbeitet, und daß die Probenahmeleitung (174) in kommunizierender Fluidverbindung mit dem Atemgassystem über das Kupplungsteil (178) und die erste Einrichtung (218) in dem Ventilelement (226) ist, und

die Rückspülleitung (174) in kommunizierender Fluidverbindung mit dem Atemgasstrom über das Kupplungsteil 178) und die zweite Einrichtung (222) in dem Ventilelement (226) ist, wenn das Kupplungsteil (178) passend mit dem zweiten Teil (210) zusammenarbeitet.

2. Vorrichtung nach Anspruch 1, bei der das Ventilelement (226) ferner einen scheibenförmigen Ventilkörper (216) mit einem zentral ausgerichteten ersten Nippel (217), welcher von der ersten ebenen Fläche nach außen verläuft, und mit einem zentral ausgerichteten zweiten Nippel (219) aufweist, welcher von einer zweiten ebenen Fläche auf der gegenüberliegenden Seite des scheibenförmigen Ventilkörpers (216) nach außen weist, die erste Einrichtung (218) eine Bohrung (218) ist, welche durch den ersten und den zweiten Nippel (217, 219) und den dazwischen liegenden Ventilkörper (216) geht, die zweite Einrichtung (222) von einer Reihe von Bohrungen (220, 222) gebildet ist, welche den Ventilkörper (216) konzentrisch zu den ersten und zweiten Nippeln (217, 219) durchsetzen, eine scheibenförmige Ventileinrichtung (226) eine zentral angeordnete Öffnung mit so ausreichender Größe hat, daß der zweite Nippel (219) in diese eintreten kann, und bei dem die Ventileinrichtung (226) ausgehend von der zweiten ebenen Fläche des Ventilkörpers (216) angeordnet und an dieser an Stellen radial außerhalb von der Reihe von Bohrungen (220, 222) befestigt ist, welche die zweite Einrichtung bilden, und bei dem die Ventileinrichtugn (226) den Fluidstrom durch die zweite Einrichtung in eine Richtung begrenzt.

3. Vorrichtung nach Anspruch 1, bei der das Ventilelement (226) ein Einrichtungsventil ist.

Revendications

1. Un système pour purger en sens inverse un filtre d'entrée (232) dans un adaptateur pour voies aériennes (106) dans un système d'échantillonnage de gaz, le système ayant un conduit d'échantillon (174) destiné à transporter à travers lui un écoulement de gaz d'échantillon provenant de l'adaptateur pour voies aériennes (106) et qui est dirigé vers des moyens d'analyse de gaz (102), l'écoulement de gaz d'échantillon traversant le filtre d'entrée (232) dans un premier sens pour entrer dans le conduit d'échantillon (176), caractérisé en ce que ce système comprend un conduit de purge en sens inverse (172) avec des moyens branchés au côté sous pression de moyens de pompage de fluide (394) et à l'adaptateur pour voies aériennes (106), et les moyens de pompage de fluide (394) sont destinés à faire circuler un fluide dans le conduit de purge en sens inverse (172), à partir des moyens de pompage de fluide (394) vers l'adaptateur pour voies aériennes (106) et à travers le filtre d'entrée (232), dans un second sens qui est opposé au premier sens, l'adaptateur pour voies aériennes comprenant un clapet (226) destiné à restreindre l'écoulement de fluide inverse dans le conduit de purge en sens inverse (172), une première section (240) comportant des moyens à travers lesquels passe un écoulement de gaz respiratoire,

une seconde section (210) fixée dans une ouverture (236) dans une paroi latérale de la première section (240) et s'étendant vers l'extérieur à partir de celle-ci, la seconde section (210) ayant une cavité centrale (212) en communication pour le fluide avec l'écoulement de gaz respiratoire qui traverse la première section (240),
le clapet (226) disposé dans la cavité (212) dans la seconde section (210), le clapet (226) comportant des premiers et seconds moyens (218, 222) pour le passage de fluide à travers eux;
le filtre d'entrée (232) disposé dans la cavité centrale (212) entre le clapet (226) et l'écoulement de gaz respiratoire avec lequel la cavité centrale (212) est en communication pour le fluide; et
des moyens (178) destinés à recevoir à l'intérieur et à raccorder le conduit de purge en sens Inverse (172) et le conduit d'échantillonnage (174), comprenant une pièce d'accouplement (178) conçue pour s'adapter hermétiquement à la cavité centrale (212) de la seconde section (210) de l'adaptateur pour voies aériennes (108), et le conduit d'échantillonnage (174) étant en communication, pour le fluide, avec le système de gaz respiratoire, par l'intermédiaire de la pièce d'accouplement (178) et les premiers moyens (218) dans le clapet (226),
et le conduit de purge en sens inverse (174) étant en communication pour le fluide avec l'écoulement de gaz respiratoire, à travers la pièce d'accouplement (178) et les seconds moyens (222) dans le clapet (226), lorsque la pièce d'accouplement (178) est adaptée à la seconde section (210).

2. Un système selon la revendication 1, dans lequel le clapet (226) comprend en outre un corps de clapet (216) en forme de disque avec un premier embout (217), aligné de façon centrale, s'étendant vers l'extérieur à partir d'une première surface plane, et un second embout (219), aligné de façon centrale, s'étendant vers l'extérleur à partir d'une seconde surface plane sur la face opposée du corps de clapet en forme de disque (216), les premiers moyens

(218) consistant en un passage (218) qui s'étend à travers les premier et second embouts (217, 219 (218)) et le corps de clapet (216) entre eux, et les seconds moyens (222) consistant en une série de passages (220, 222) à travers le corps de clapet (216), concentriques par rapport aux premier et second embouts (217, 219), et un obturateur en forme de disque (226) ayant une ouverture centrale de taille suffisante pour permettre le passage du second embout (219), l'obturateur (226) partant de la seconde surface plane du corps de clapet (216) et étant fixé à celui-ci dans des positions situées, en direction radiale, à l'extérieur de la série de passages (220, 222) qui constituent les seconds moyens, l'obturateur (226) restreignant à un seul sens l'écoulement de fluide à travers les seconds moyens.

3. Un système selon la revendication 1, dans lequel le clapet (226) est un clapet unidirectionnel.

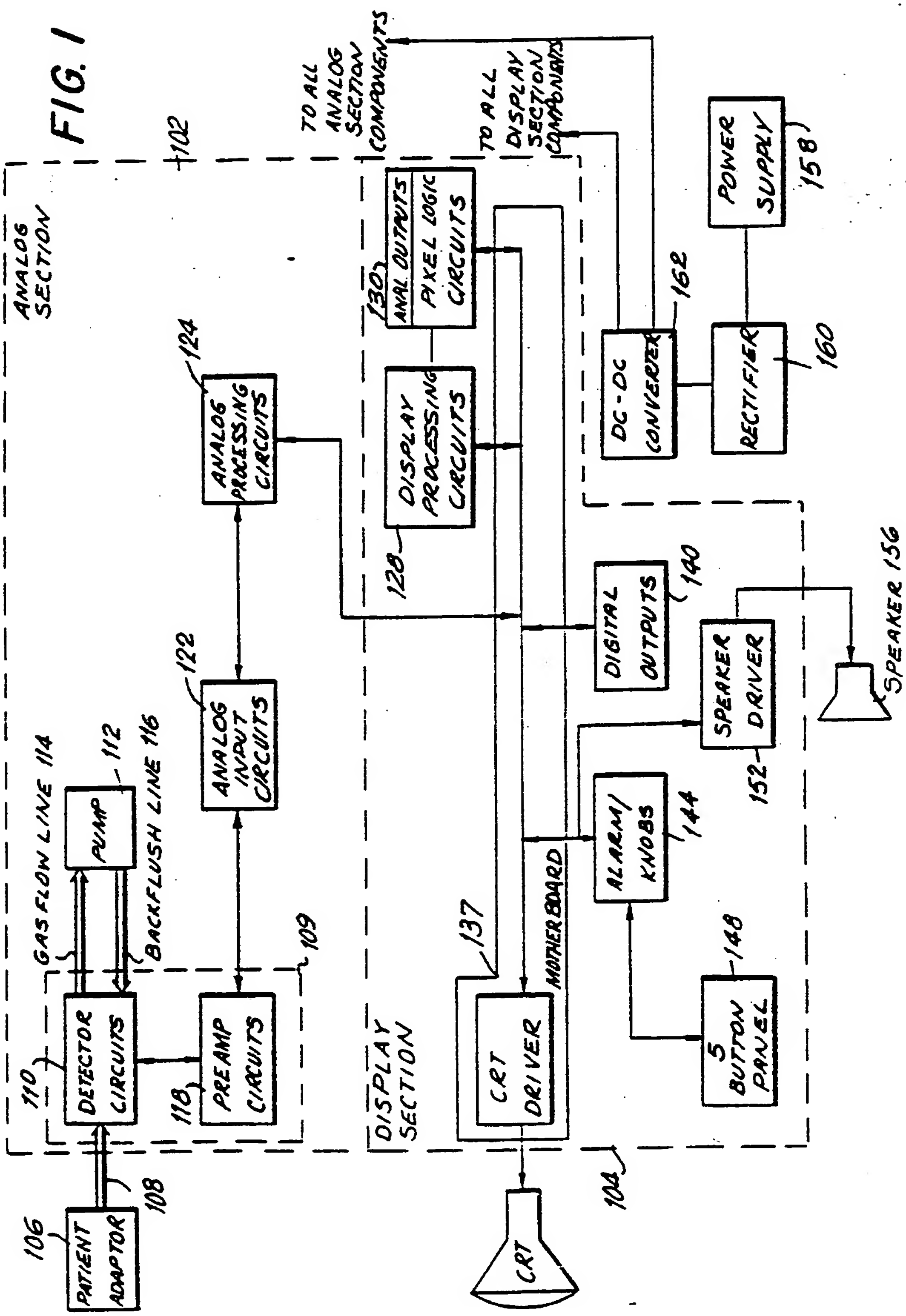

ANALOG SECTION
102
PATIENT ADAPTOR
106
108
DETECTOR CIRCUITS
110
PREAMP CIRCUITS
118
109
PUMP
112
GAS FLOW LINE 114
BACKFLUSH LINE 116
ANALOG INPUT CIRCUITS
122
ANALOG PROCESSING CIRCUITS
124
TO ALL ANALOG SECTION COMPONENTS
TO ALL DISPLAY SECTION COMPONENTS
ANAL OUTPUTS
PIXEL LOGIC CIRCUITS
130
DISPLAY PROCESSING CIRCUITS
128
DISPLAY SECTION
CRT DRIVER
137
MOTHER BOARD
CRT
104
DIGITAL OUTPUTS
140
ALARM/KNOBS
144
5 BUTTON PANEL
148
SPEAKER DRIVER
152
SPEAKER 156
DC-DC CONVERTER
162
RECTIFIER
160
POWER SUPPLY
158

FIG. 1

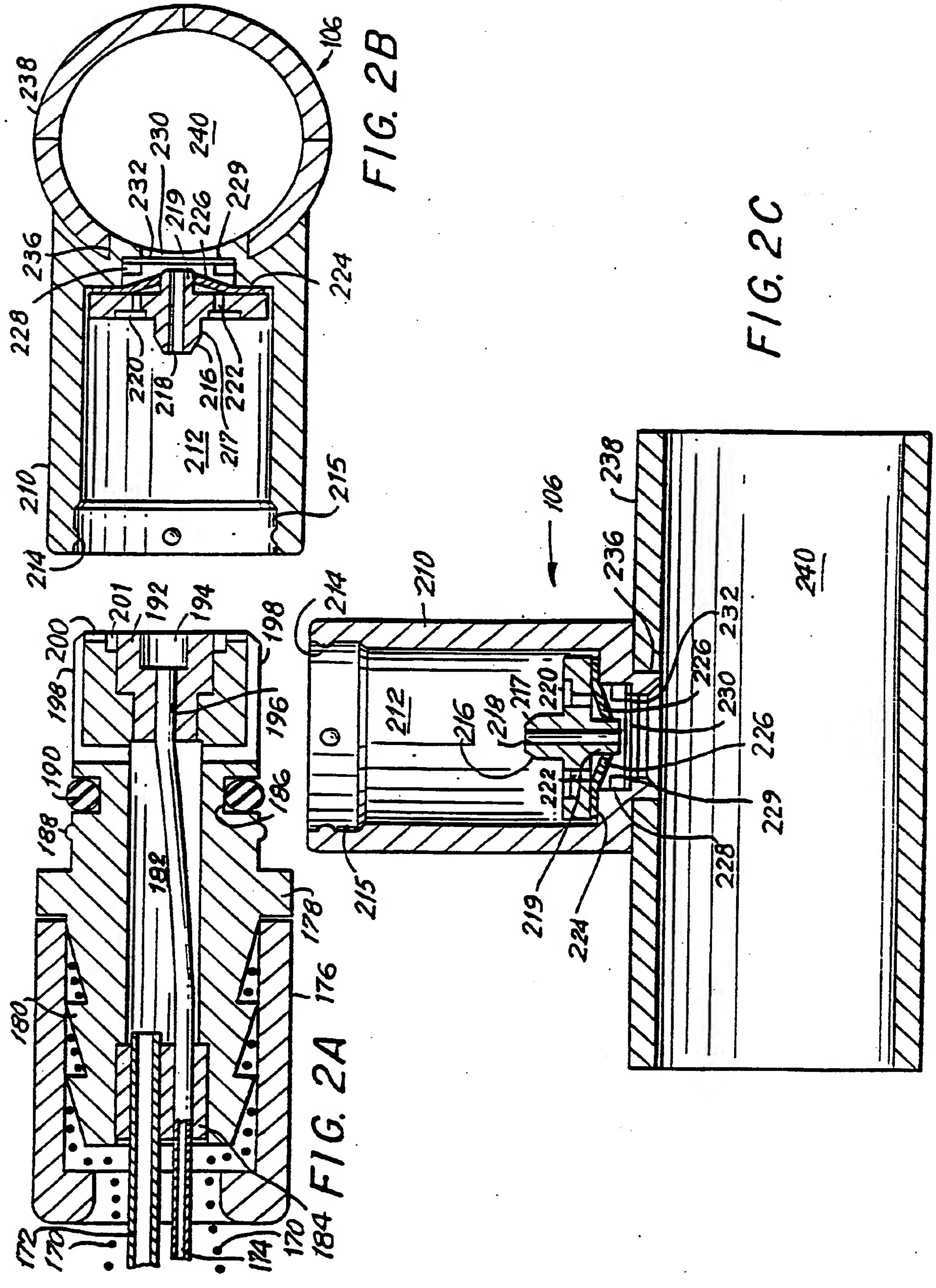


FIG. 2A

FIG. 2B

FIG. 2C

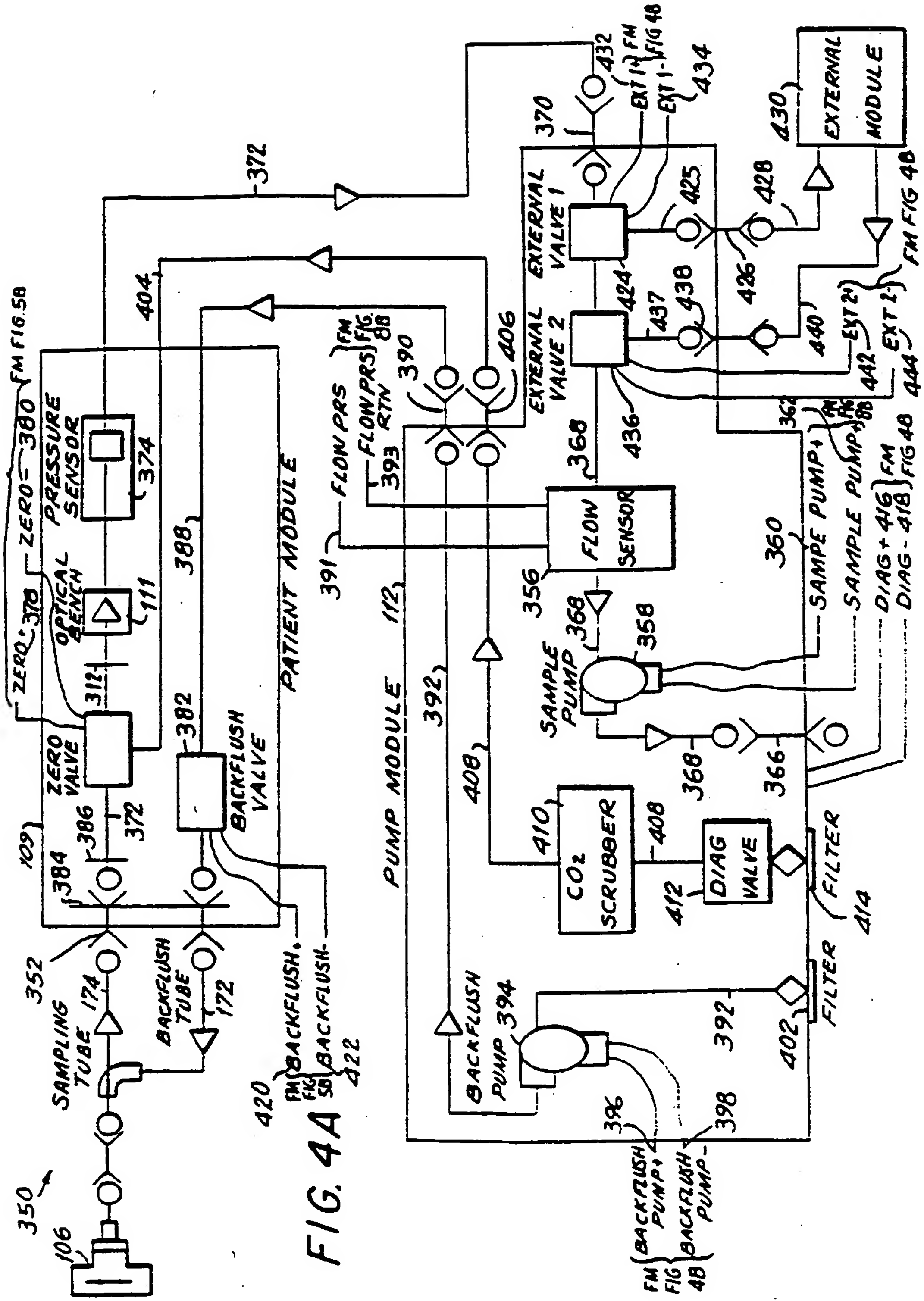

PATIENT MODULE
PUMP MODULE
ZERO VALVE
BACKFLUSH VALVE
OPTICAL BENCH
PRESSURE SENSOR
FLOW SENSOR
SAMPLE PUMP
BACKFLUSH PUMP
CO2 SCRUBBER
DIAG VALVE
FILTER
EXTERNAL VALVE 1
EXTERNAL VALVE 2
EXTERNAL MODULE
SAMPLING TUBE
BACKFLUSH TUBE
FLOW PRS
FLOW PRS RTN
SAMPLE PUMP+
SAMPLE PUMP-
DIAG+
DIAG-
BACKFLUSH+
BACKFLUSH-
BACKFLUSH PUMP+
BACKFLUSH PUMP-
ZERO+
ZERO-
EXT 1+
EXT 1-
EXT 2+
EXT 2-
FM FIG 5B
FM FIG 8B
FM FIG 4B

FIG. 4A

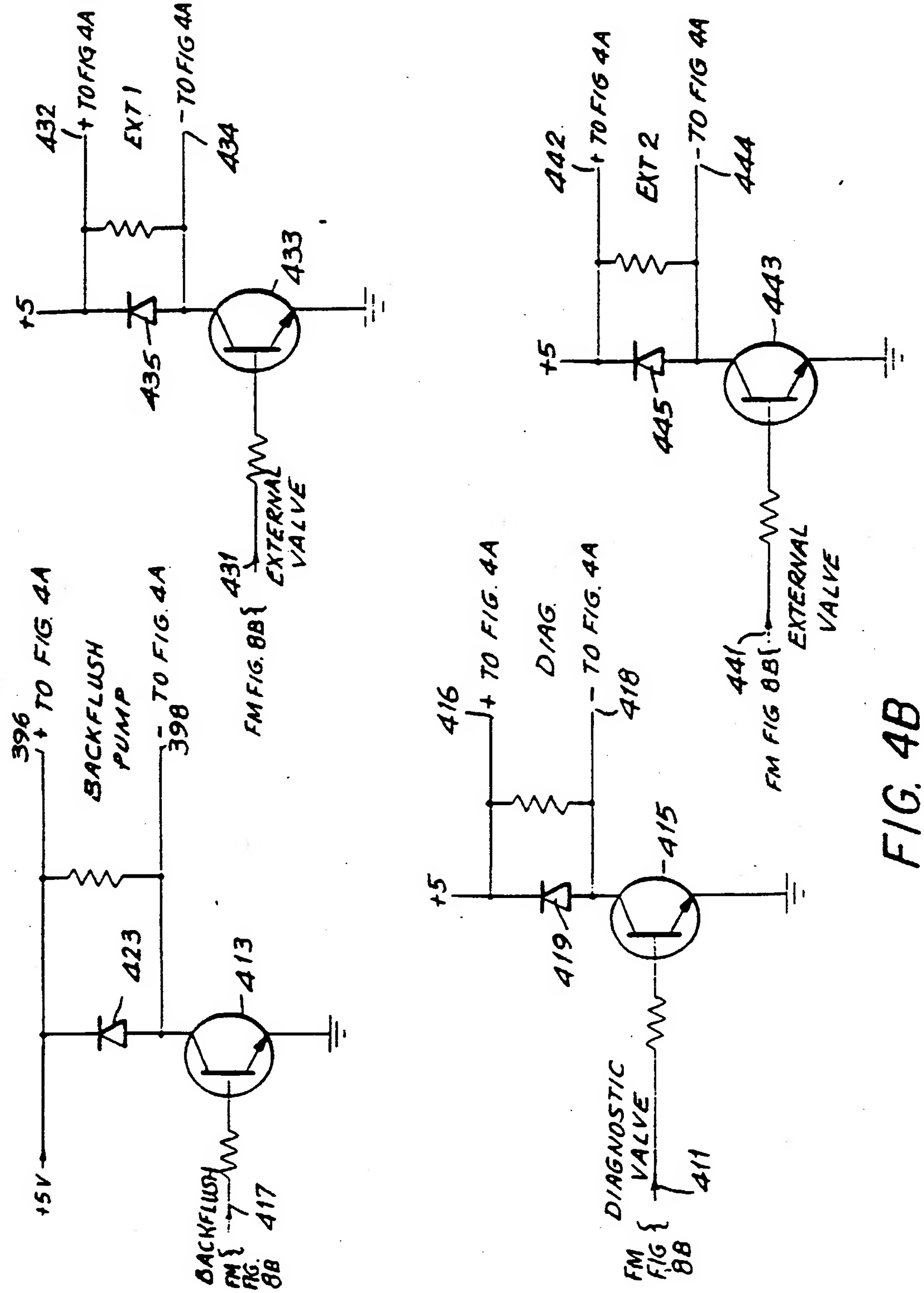

+5V
BACKFLUSH
FM FIG. 8B
417
413
423
396
+ TO FIG. 4A
BACKFLUSH
PUMP
- TO FIG. 4A
398
+5
435
433
432
+ TO FIG 4A
EXT 1
- TO FIG 4A
434
431
EXTERNAL
VALVE
FM FIG. 8B
DIAGNOSTIC
VALVE
411
FM FIG 8B
+5
419
415
416
+ TO FIG. 4A
DIAG.
- TO FIG. 4A
418
+5
445
443
442
+ TO FIG 4A
EXT 2
- TO FIG 4A
444
441
FM FIG 8B
EXTERNAL
VALVE

FIG. 4B

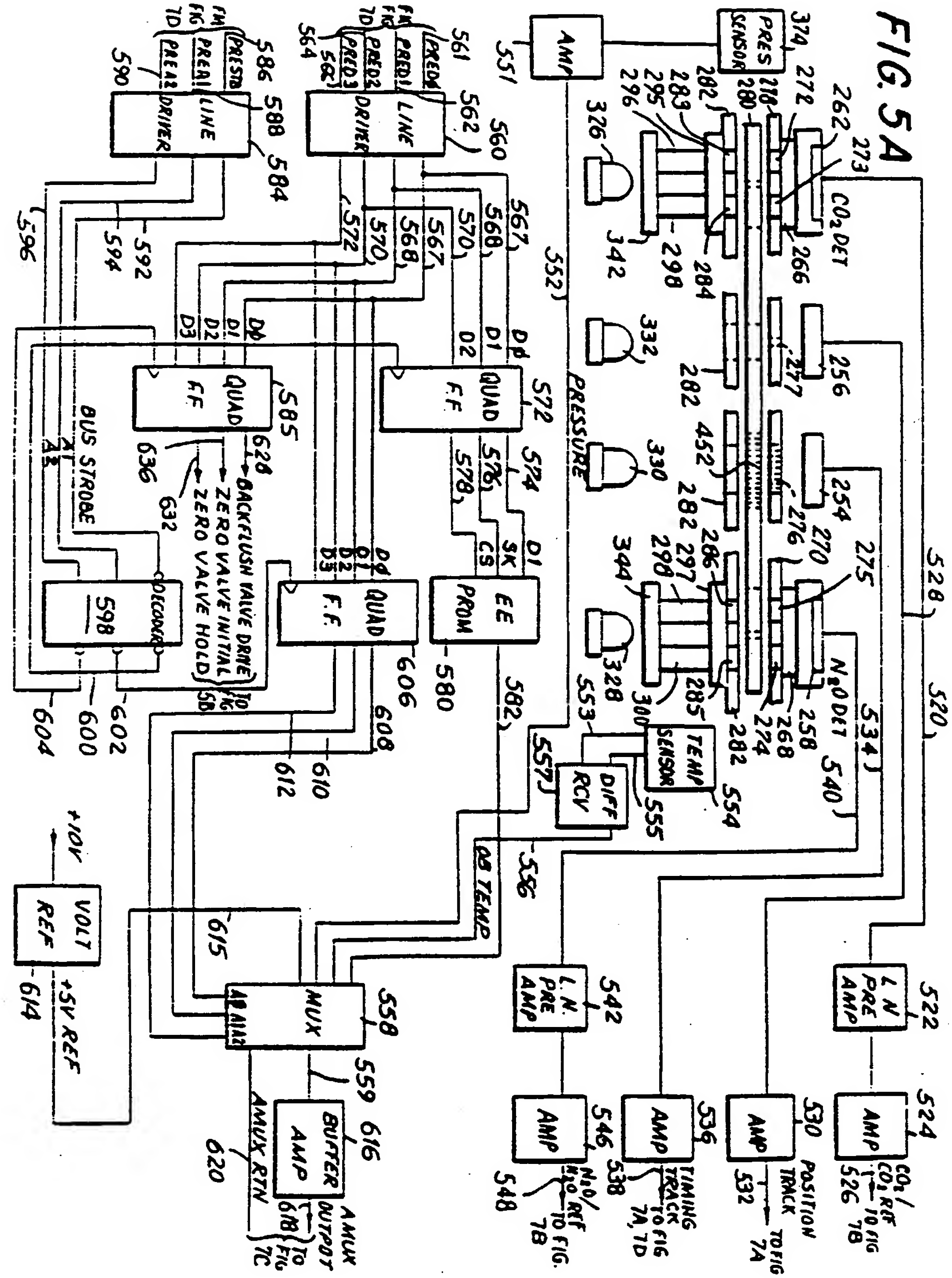

PRES SENSOR
AMP
CO2 DET
N2O DET
PRESSURE
TEMP SENSOR
DIFF RCV
DB TEMP
LINE DRIVER
PRED1
PRED2
PRED3
PRED4
PRESTB
PREA1
PREA2
QUAD F.F.
EE PROM
DECODER
BUS STROBE
BACKFLUSH VALVE DRIVE
ZERO VALVE INITIAL
ZERO VALVE HOLD
L.N. PRE AMP
MUX
BUFFER AMP
VOLT REF
+10V
+5V REF
AMUX OUTPUT
AMUX RTN
POSITION TRACK
TIMING TRACK
CO2/CO2 REF
N2O/N2O REF

FIG. 5A

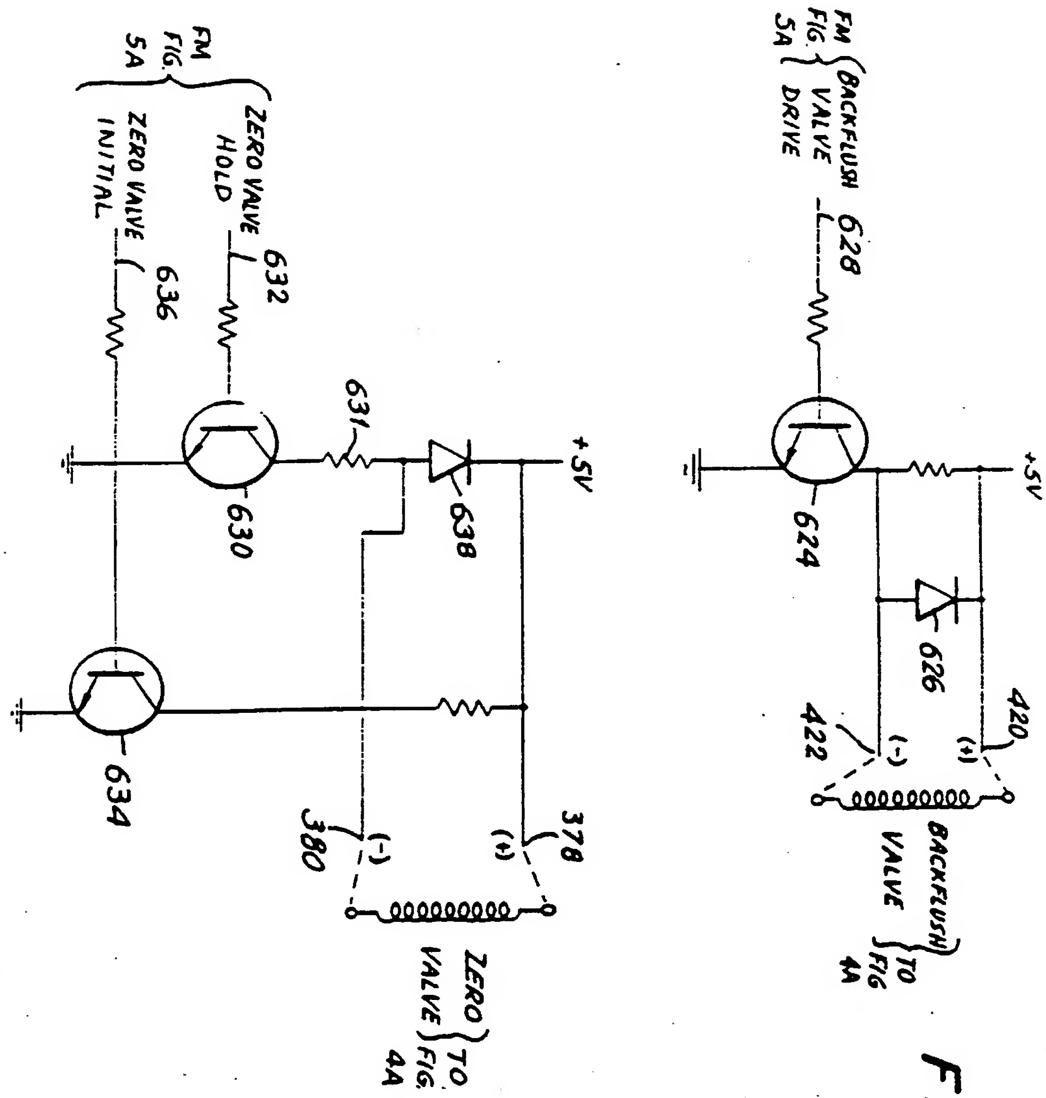

FM FIG. 5A
BACKFLUSH VALVE DRIVE
628
624
+5V
626
420
422
(+)
(-)
BACKFLUSH VALVE
TO FIG 4A
FM FIG. 5A
ZERO VALVE HOLD
632
ZERO VALVE INITIAL
636
631
630
+5V
638
634
378
380
(+)
(-)
ZERO VALVE
TO FIG. 4A

FIG. 5B

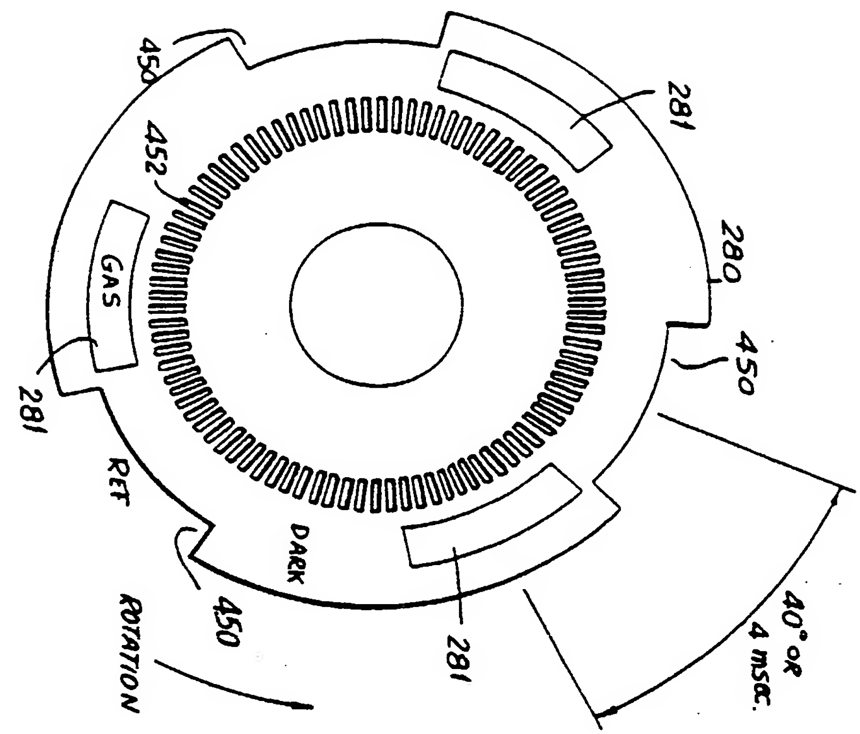

450
452
GAS
281
REF
DARK
450
ROTATION
281
40° OR 4 msec.
450
280
281

FIG. 6A

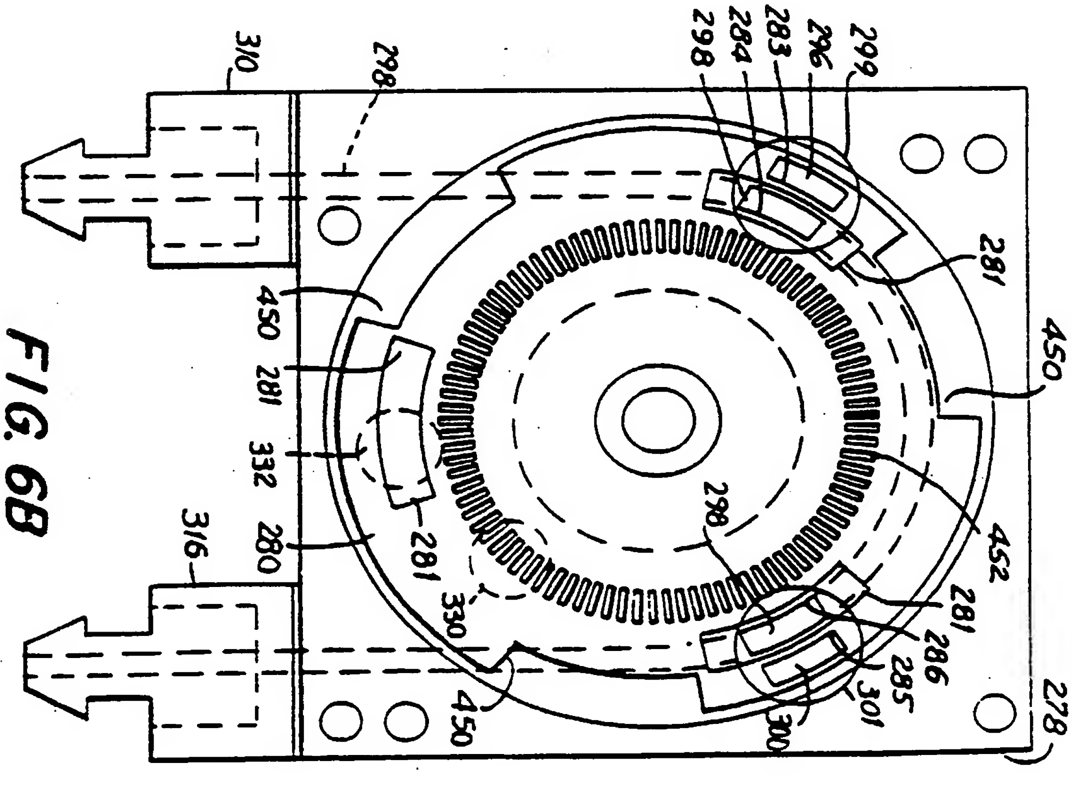
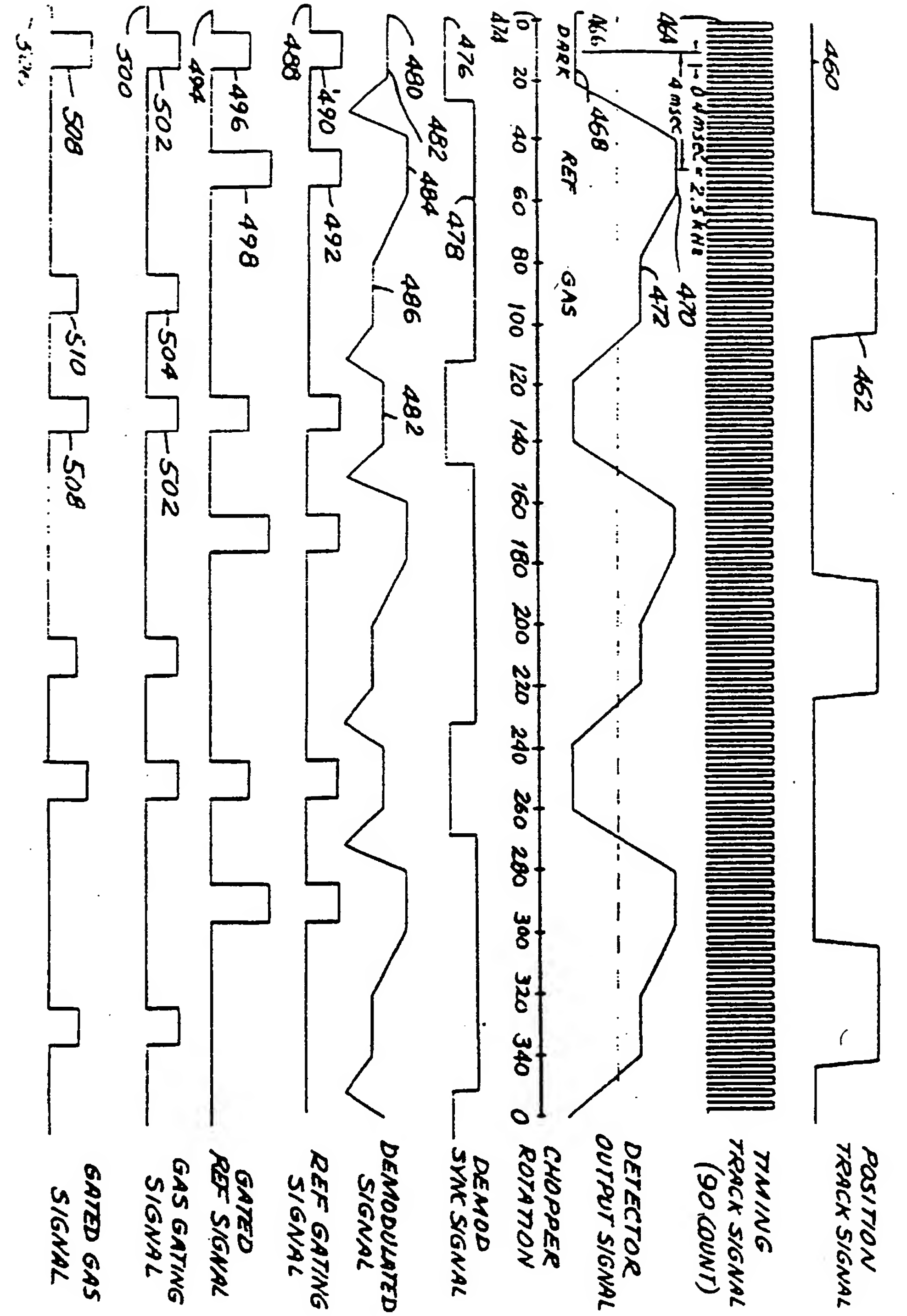

310
298
298
284
283
296
299
281
450
450
281
332
280
281
316
330
450
296
452
281
286
285
301
300
278

FIG. 6B

FIG. 6C


POSITION TRACK SIGNAL
TIMING TRACK SIGNAL (90 COUNT)
DETECTOR OUTPUT SIGNAL
CHOPPER ROTATION
DEMOD SYNC SIGNAL
DEMODULATED SIGNAL
REF GATING SIGNAL
GATED REF SIGNAL
GAS GATING SIGNAL
GATED GAS SIGNAL
DARK
REF
GAS

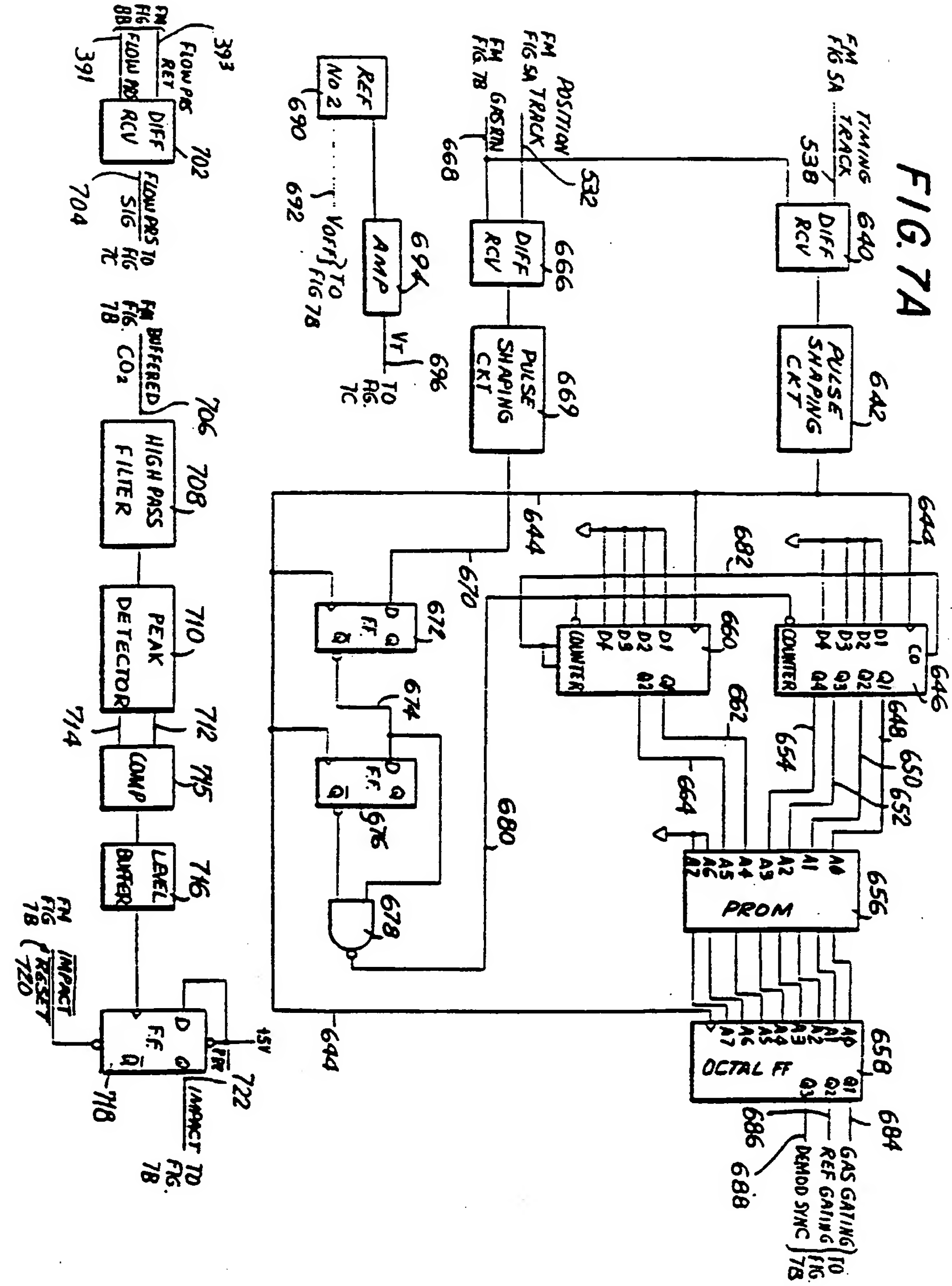

DIFF RCV
PULSE SHAPING CKT
DIFF RCV
PULSE SHAPING CKT
COUNTER
COUNTER
PROM
OCTAL FF
REF No 2
AMP
F.F.
F.F.
DIFF RCV
HIGH PASS FILTER
PEAK DETECTOR
COMP
LEVEL BUFFER
F.F.
GAS GATING
REF GATING
DEMOD SYNC

FIG. 7A

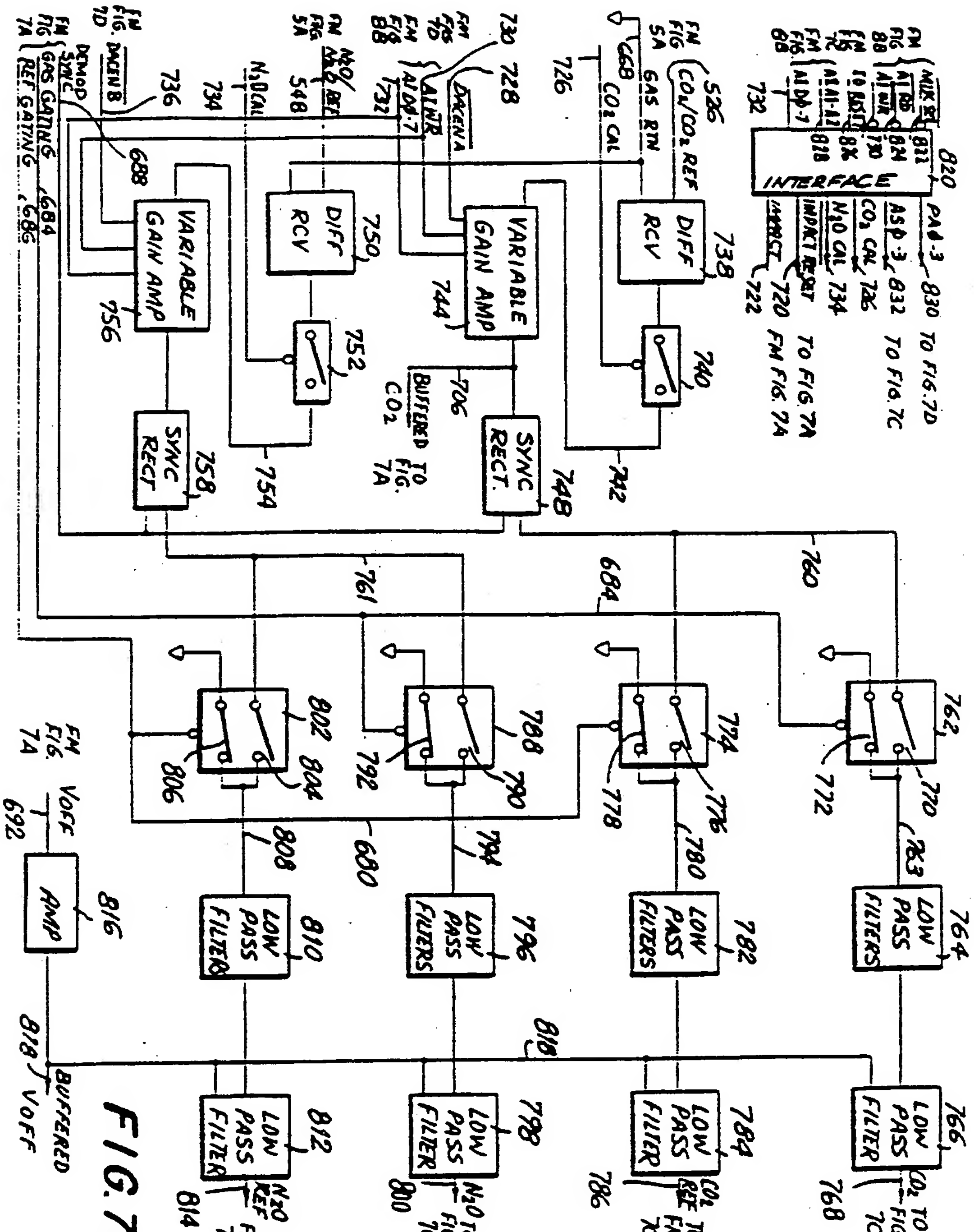

INTERFACE
DIFF RCV
VARIABLE GAIN AMP
SYNC RECT.
LOW PASS FILTERS
LOW PASS FILTER
AMP
BUFFERED V OFF

FIG.7B

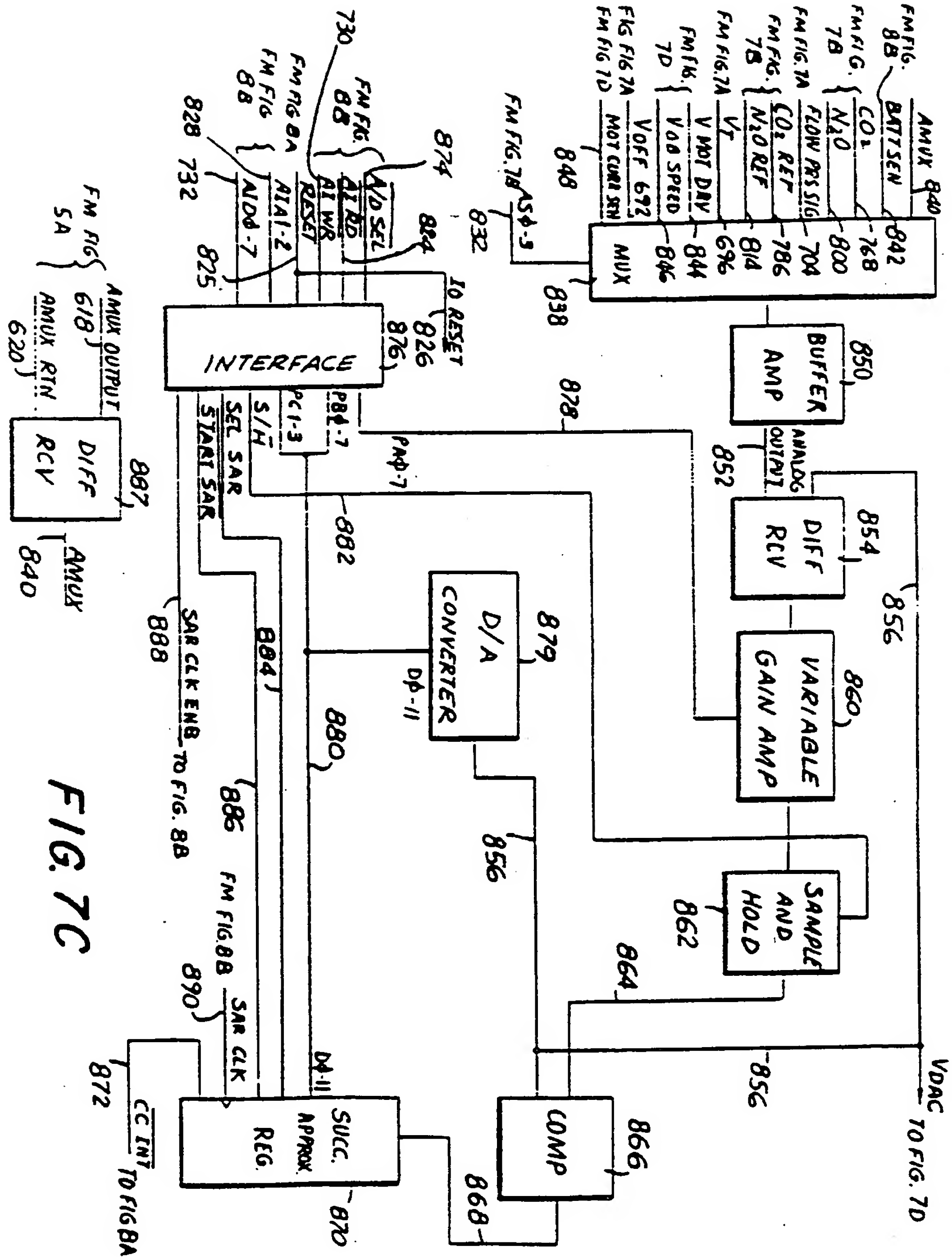

AMUX 840
BATT SEN
CO2
N2O
FLOW PRS SIG
CO2 REF
N2O REF
VT
V MOT DRV
VAB SPEED
VOFF 692
MOT CURR SEN
ASΦ-3
MUX
BUFFER AMP
ANALOG OUTPUT
DIFF RCV
VARIABLE GAIN AMP
SAMPLE AND HOLD
COMP
D/A CONVERTER
DΦ-11
SUCC. APPROX. REG.
INTERFACE
A/D SEL
AI RD
AI WR
RESET
AIAΦ-2
AIDΦ-7
IO RESET
PBΦ-7
PC1-3
S/H
SEL SAR
START SAR
SAR CLK ENB
SAR CLK
CC INT
VDAC
AMUX OUTPUT
AMUX RTN
AMUX
TO FIG. 7D
TO FIG. 8B
TO FIG 8A

FIG. 7C

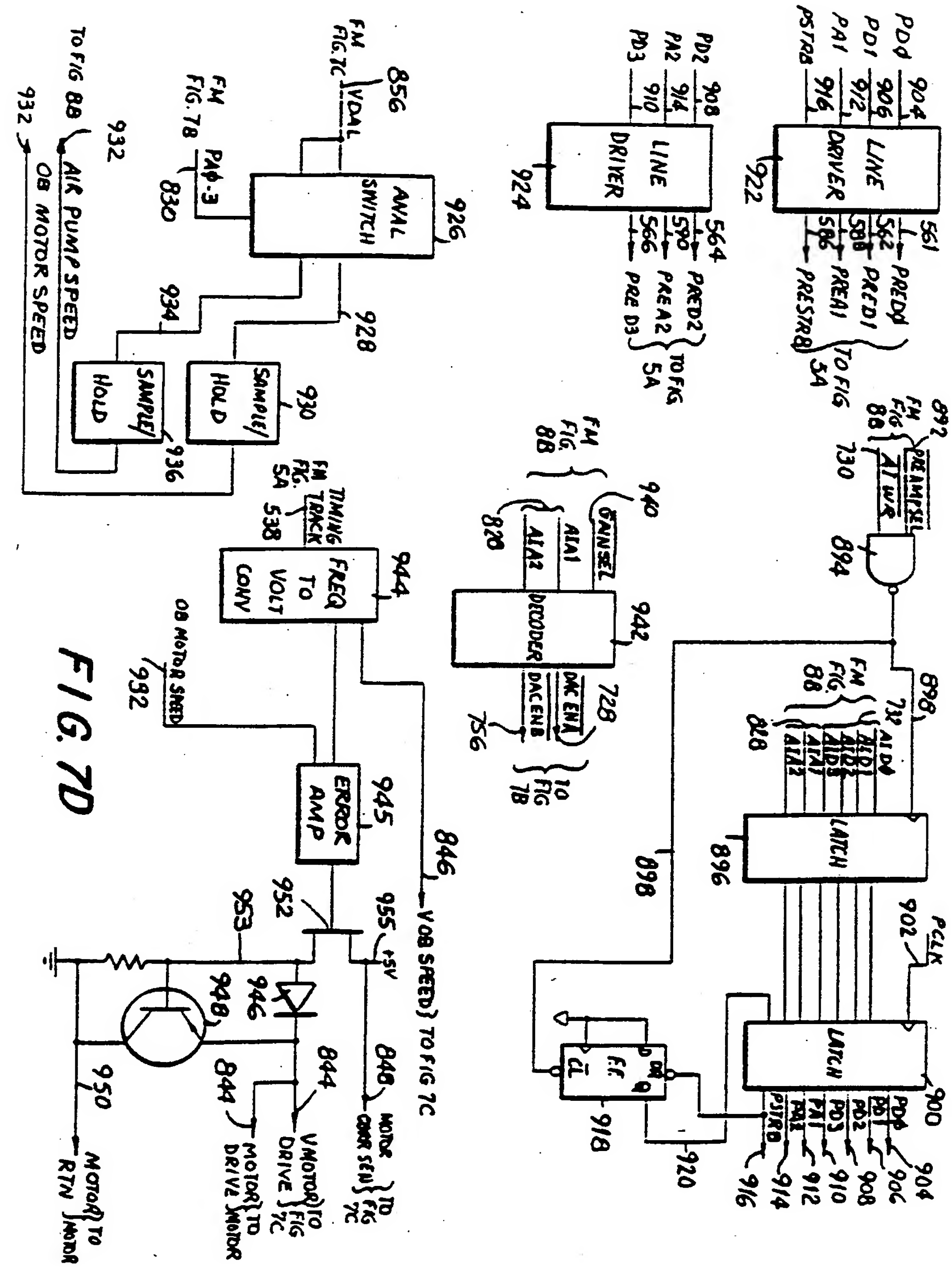


FIG. 7D

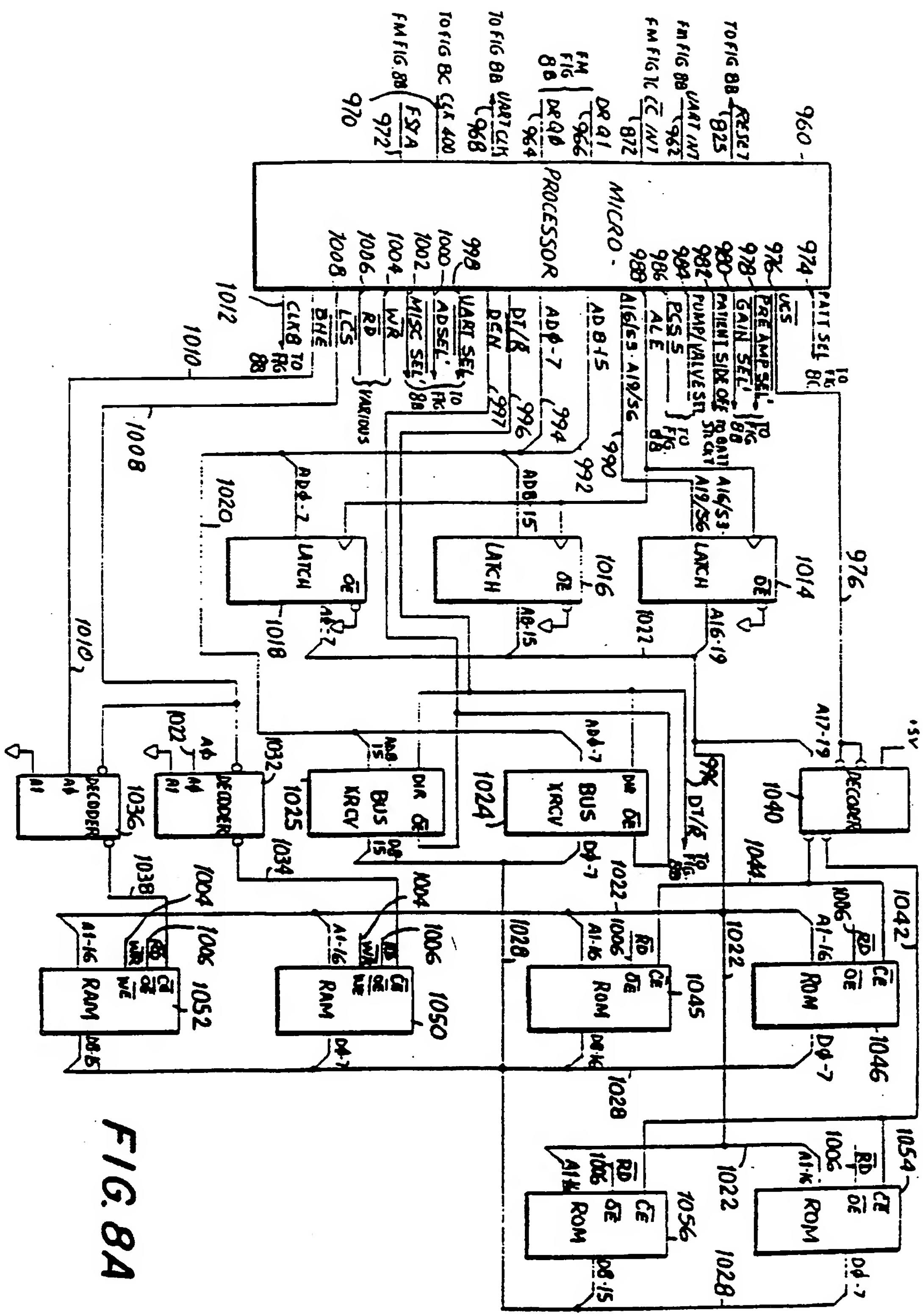

MICRO-PROCESSOR
960
LATCH
1014
LATCH
1016
LATCH
1018
BUS XRCV
1024
BUS XRCV
1025
DECODER
1040
DECODER
1032
DECODER
1036
ROM
1046
ROM
1045
ROM
1054
ROM
1056
RAM
1050
RAM
1052
TO FIG 8B
FM FIG 7C
TO FIG 8C
FM FIG 8B
RESET
UART INT
CE INT
DRQ1
DRQ0
UART CLK
CLK 400
FSYA
UCS
PRE AMP SEL
GAIN SEL
PUMP/VALVE SEL
PCS 5
ALE
AD0-7
AD8-15
DT/R
DEN
UART SEL
ADSEL
MISC SEL
WR
RD
LCS
BHE
CLK8 TO FIG 8B
+5V

FIG. 8A

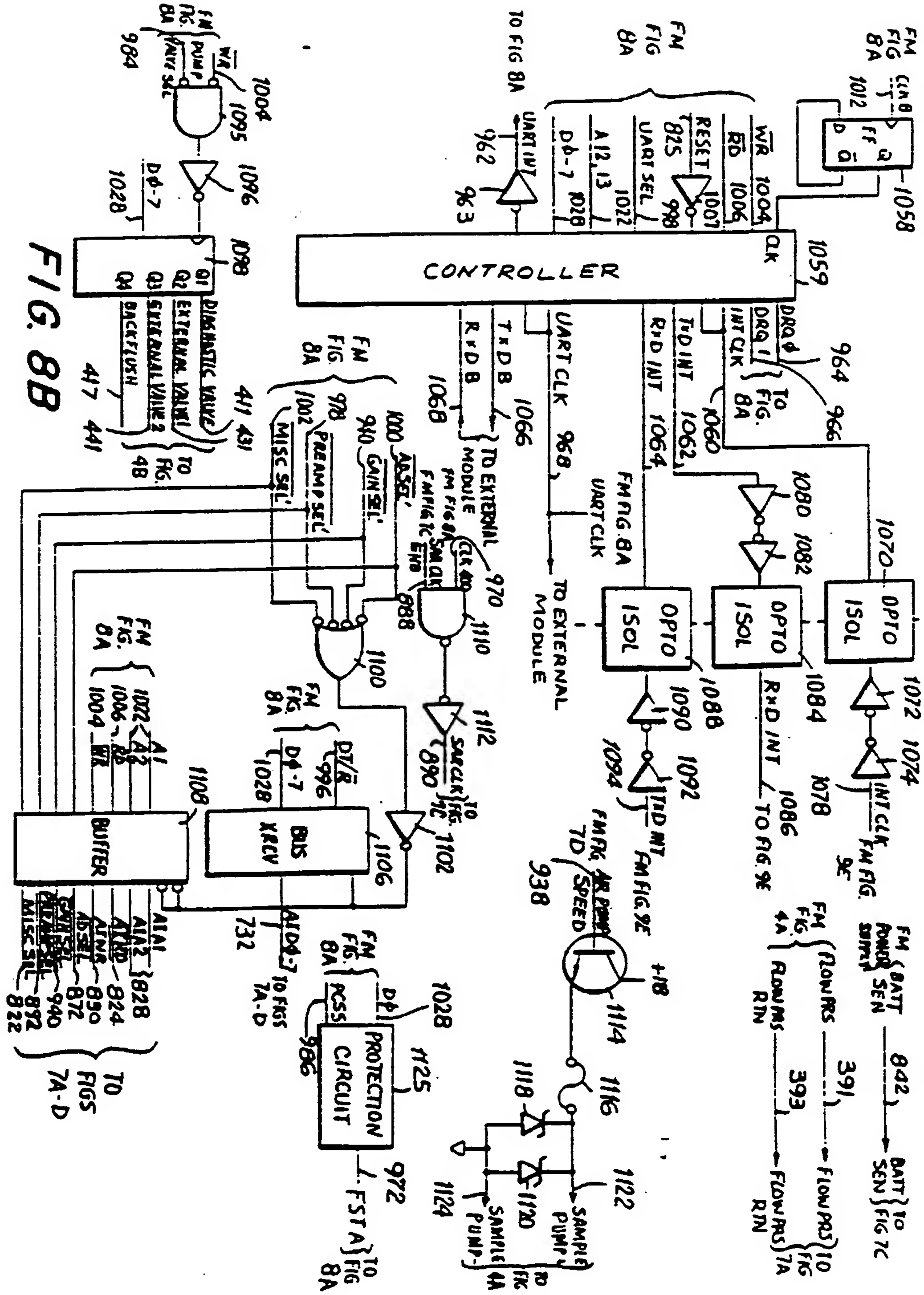

CONTROLLER
OPTO ISOL
OPTO ISOL
OPTO ISOL
BUFFER
BUS XRCV
PROTECTION CIRCUIT
TO EXTERNAL MODULE

FIG. 8B

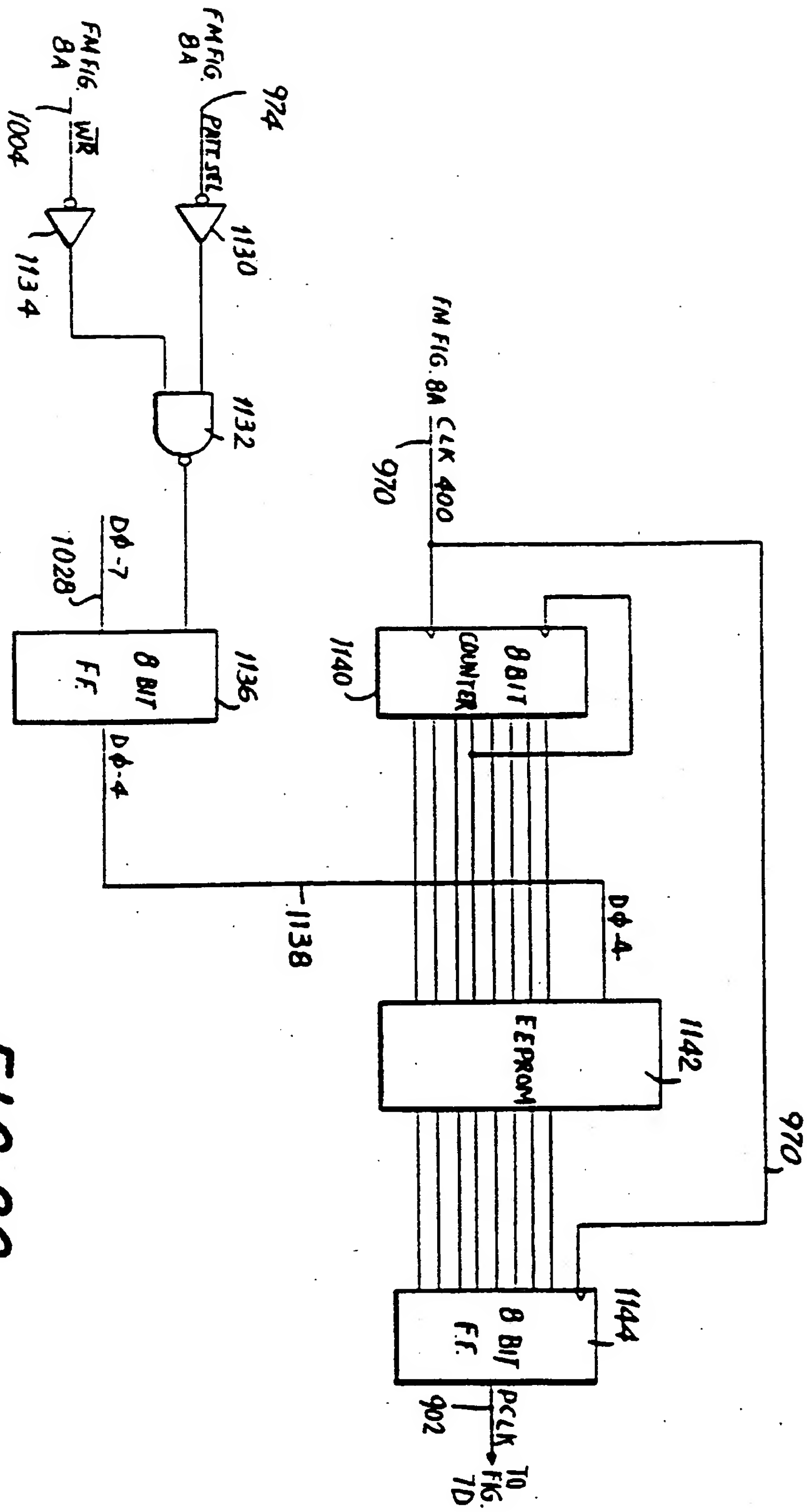

FM FIG. 8A
974
PART SEL
1130
FM FIG. 8A
WR
1004
1134
1132
FM FIG. 8A CLK 400
970
Dφ-7
1028
8 BIT F.F.
1136
Dφ-4
8 BIT COUNTER
1140
1138
Dφ-4
EEPROM
1142
970
8 BIT F.F.
1144
PCLK
902
TO FIG. 7D

FIG. 8C

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